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AN ELECTROMYOGRAPHIC STUDY OF THE BEHAVIOR OF THE MASSETER MUSCLE IN RESPECT TO THE UTILIZATION OF SPIRAL-SPRING RETENTION FOR COMPLETE DENTURES

by

Ⓒ Normand Tardif

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE IN DENTISTRY

DEPARTMENT OF PROSTHODONTICS

FACULTY OF DENTISTRY

EDMONTON, ALBERTA

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ABSTRACT

An electromyographic study was undertaken on five edentulous subjects provided with complete dentures bearing calibrated bilateral swivels and springs in order to test whether the springs affected muscle activity. Electromyograms of the right and left masseter muscles were recorded over ten successive days before and after temporary removal of the springs. During the electromyographic recording period, subjects were asked to apply, in centric occlusion, moderate occlusal pressure (isometric contraction). The spring tension was recorded each day for varying inter-swivel distances giving a force range of 90 - 100 grams during function. An average electromyographic tracing distance for a constant period (2.5 sec = 15 mm) was compared for subjects with and without springs.

The electromyographic activity obtained with springs was significantly different from that obtained without springs. The addition of springs resulted in a reduction in electromyographic activity of the masseter muscle during isometric contraction.

There was also a significant interaction between patients and muscles.

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INTRODUCTION

The development of complete denture stability during oral function constitutes one of the most interesting and challenging phases in prosthetic dentistry. For centuries, dentists have been investigating methods and procedures that would enhance denture stability. The application of spiral springs is one method.

It is speculated that the utilization of spiral springs may introduce a change in the sensory and motor activity of the stomatognathic system. Because the springs function in opposition to the elevator muscles, these appliances may alter or modify the sensory and motor activity through the afferent and efferent connections of the masticatory muscles in the central nervous system.

Dentistry, because of its specialized knowledge of, and its concern for, the stomatognathic system has a responsibility to contribute scientific information concerning the effect of prosthetic appliances on associated physiological activity.

PURPOSE OF THE INVESTIGATION

The purpose of this study is to test the hypothesis that a specific denture modification (addition of spiral springs) influences the sensory and motor activity of the muscle as evinced by the degree of electromyographic activity in muscle (masseter muscle).

STATEMENT OF THE PROBLEM

1. WITHOUT SPRINGS vs WITH SPRINGS:

To compare electromyograms obtained from the isometric contraction of the masseter muscle, when an edentulous subject is clenching moderately in centric occlusion, first without springs incorporated into complete dentures, and secondly with springs incorporated into complete dentures.

2. PATIENT VARIABILITY:

To determine whether or not a significant degree of variability occurred in EMG presentation of five subjects.

3. LEFT vs RIGHT MASSETER MUSCLES:

To determine whether or not there was a different degree of EMG performance between right and left masseter muscles.

REVIEW OF LITERATURE

SPIRAL SPRINGS

The utilization of spiral springs is probably the oldest retaining method used in denture prosthetics. As early as in the first part of the eighteenth centure (1737), Pierre Fauchard, the father of dentistry, was using flat steel and coiled-gold wire springs for the retention of complete dentures.[1] Thomas Berdmore, in 1768, introduced his detachable springs that differed from those used by his predecessor; this difference was represented by his claim that they exerted an equal pressure on the denture bases, and also that they followed all the various movements of the mandible.[1] Massey, in 1772, conceived an apparatus made out of four springs (two on each side of the dentures). This means of retention proved to be complicated and apparently was not developed further.[1]

Dubois de Chenant, in 1789, described his springs as being able to allow side motion, and even that of rotation.[2]

A further advancement was made almost three-quarters of a century later. In 1843, Dr. Solyman Brown reported that springs were attached to a "standard" which was fixed to the denture base near the first bicuspid or the first molar. Sometimes it was required that the "standard" on the upper denture be placed either forward or backward in relationship to those on the lower denture.[3]

Some practitioners, reported by Brown in 1843, tried bicuspids with pivot holes passing through them. But the mineral teeth were frequently broken by the pivots and this method has since been abandoned.[3]

Dr. Brown also reported that since it was a problem to find out the exact center for attachment of the fixed points of the springs, a slide socket, extending from the first bicuspid to the first molar, was soldered to the denture bases replacing the fixed "standards".[3]

It is interesting to note that during the time-period referred to above, spiral springs of gold, silver, and copper were sometimes formed in private-practice offices by coiling a wire of the size of a needle over a mandrel or a steel rod. Also, manufacturers of dental apparatus, utilizing a machine constructed specifically for this purpose, constructed springs for the commercial dental market.[3-4]

In 1872, Burrows brought in a new kind of spring made of soft elastic rubber with the two ends of hard vulcanite. These springs were light in weight and not subject to breakage.[5] At that same period, other practitioners, to prevent abrasion of the cheek, painted their springs with a solution of "pink rubber".[6] But a few years later (1896), Coxon reported that rubber tubes placed over the springs were unsatisfactory because the increase in friction caused irritation to the mucosa.[7]

In 1878, Hempel developed a new mode of mounting swivels and springs. The springs had their ends fixed in gold boxes. Loops (made on the principle of necklace-fastener), bolts, and springs were detachable, so that a patient could easily remove the apparatus for cleansing and for the replacement of a broken spring.[8] In 1879, Harris presented his detachable spring which consisted of a gold wire with a double coil in the center. The spring

rotated upon a swivel which could slide in a carrier, the latter being fixed to the dentures.[9] Rogers's invention (1879) was also a detachable spring forced upon a shank which rotated on a slender axis. This particular shank was shorter than the ordinary swivel, thus diminishing strain on the spring and avoiding a tendency of movement of the dentures.[10] In 1892, Stedman's spring consisted of a spiral spring enclosed in a nickel tube (about one-half an inch in length) with a cap through which passed the pivot, to which motion was given by the spring.[11]

We should notice that springs of different sizes were used at that particular time. For instance in 1891, a gold spring wire of about 18 gauge was in use; and in 1896, a platinum-gold wire from No. 24 to 30 gauge was utilized.[12-13]

There was a generalized decrease in the utilization of springs towards the end of the nineteenth century; it appears that at this time more than at any other previous period, they were critically evaluated because they were troublesome: e.g. springs were so long that they were folding the wrong way; they caused injury to the mucosa by pinching action;[14] they frequently fractured; and they had a predisposition to food collection. Many practitioners began to limit the use of springs to very special cases such as pronounced maxillary resorption, "inadaptation to a large suction plate", or cleft-palate cases.[13] Nevertheless, it is reported that "Messrs Ash & Sons Company" (1896) were making between ten and twenty thousand pairs of springs annually.[7]

A major problem encountered by those who advocated the use of springs was that of deciding upon the most "mechanically-

advantageous" location of the swivel-bolts in the denture bases. There have been different opinions on this matter. Some claimed that for the upper denture base, the springs must be placed as near as possible to the center of gravity of the first and second bicuspid; and for the lower denture-base, in the prolongation of a perpendicular drawn from the center of gravity of the upper denture base.[4] In 1912, Douglas and Gabell, after investigating various locations for the swivels, came to the conclusion that the correct position was that where the upper swivel was placed well forward and the lower one a "little back".[15]

Another method was suggested by Lennox in 1923. He placed the bolts in the lower denture base just below the center of the second bicuspid or slightly forward of that point. The bolts in the upper denture base were placed vertically over those in the lower or slightly backward.[16]

A new development concerning springs came from Germany in 1959.[17] It consisted of a rounded stainless steel spring bow, having the form of a perfect "U" when the denture teeth are in centric occlusion. Each denture was fitted with only 12 teeth to receive the spring bow; each spring bow was fastened to "cannulas" and anchored to the cuspids and first bicuspids. The lateral displacement was minimized because all forces exerted against the denture base were perpendicular to the occlusal surface.

Today, the spring mechanism generally employed consists of two coiled stainless steel springs (each approximately two inches long) and four swivels embedded into a plastic denture base in the premolar region. The springs exert a positive seating pressure on

both the maxillary and mandibular dentures.[18]

ELECTROMYOGRAPHY

In order to measure the bioelectric features associated with muscular contraction, various instruments have been developed during the past eighty years.

Du Bois-Reymond (1849) was the first one to have demonstrated the electrical activity of muscles, under voluntary contraction, in humans.[19] The two ends of a very sensitive galvanometer were connected to two homogenous platinium plates which were immersed in glass jars filled with salt-water. Each forefinger of both hands, of the same person, were introduced into the jars. The contraction of each arm produced a deflection of the needle of the galvanometer.

Not until 1875 ~~was~~ a more scientific device developed; the "Lippman's capillary electrometer". A capillary tube, partly filled with mercury, contacted dilute sulfuric acid. Small differences of potential, between the mercury and the acid, allowed the mercury to move. An illuminating system projected pictures on a photokymograph, giving a permanent record.[20]

In 1906, Einthoven brought in his string galvanometer. It consisted of a gilded quartz fiber, suspended in a small closed gap between the poles of a powerful electromagnet. Passage of a current through the fiber caused it to bend at a right angle to the plane of the magnetic field.[21] During this period, study of action potentials of nerves was delayed by lack of speed and sensitivity in recording instruments.

In 1908, Buchanan, using a capillary electrometer, observed and recorded on photographic paper, the intrinsic electrical properties of skeletal muscle of the masseter during contraction, by surface electrodes.[22]

Later, in 1937, the action-currents were amplified by the discovery of the vacuum tube. Scientific advancements resulted in the development of the high frequency oscillograph, which is essentially an amplifier and a recording device (such as a pen-writer).[23]

MUSCLE PHYSIOLOGY

To understand the physiologic basis of electromyography, an understanding of some of the properties of muscle is essential. The electromyograph depends upon alteration in the electrical polarity of the cell membrane immediately prior to contraction, i.e. depolarization. At rest, the outer surface of the muscle is positive while the inner surface is negative. When a muscle contracts, a wave of exitation or negativity is passed along the surface of the fiber. Following depolarization, electrical currects are produced as a result of the alteration in the permeability of the membrane to ions, particularly Na^+ and K^+. The electrical events induce an intracellular release of Ca^{++} ions, which interact with the muscle proteins to produce contraction. The change in potential slightly precedes contraction and is referred to as a muscle action potential or voltage. The basic functional unit of muscular activity is the motor unit which is defined by Sherrington as "an anterior cell, its axon and terminal branches together with the muscle fiber

supplied by it".[24]

Not all motor units are of the same size. Hence, different sizes govern the response and force of contraction of a muscle. The innervation ratio, i.e. the proportion of muscle fibers to a motor unit varies over a wide range. A muscle such as the extraocular muscle undergoing delicate or finely adjusted movement requires precise control, and hence has a ratio of one motor neuron to six muscle fibers for example. While in the masseter, where movements are slower and less finely adjusted than those of the eye, the innervation ratio varies from one to 640.[25-26]

Since the motor unit is liable to the "all or none law"[27] i.e., it contracts maximally or not at all, the smoothness of gradation in contraction is assured by asynchronous activity of several motor units.[28]

Forbes has suggested that motor units act in rotation[29], and this has been attributed to a difference in the length of the axon branches.[23] The action potential, or voltage, possesses the following characteristics: frequency, amplitude, and duration which change in form for different contraction.[23] The rate of discharge, or frequency, normally varies from five to twenty per second such as demonstrated by Adrian and Bronk[30], but rates up to fifty per second has been observed by Bigland and Lippold.[31]

The duration of contraction of a motor unit spike potential has been established to vary between 2 - 10 milliseconds; voltage between 100 - 2000 microvolts have been recorded by monopolar electrodes.[32]

The amplitude of the spikes, as well as the frequency, augment with increasing effort.[28] The ability of a muscle to deliver a

maximal contraction is directly proportional to the number of motor units capable of contraction at any one time.[27] Inman and Ralston showed electromyographically that there is parallelism between tension and electromyogram (EMG) in a muscle at a fixed length (isometrically).[33]

Thus by means of electromyography, the activity of the motor unit can be analysed, and it is not surprising that this versatile tool has been used in dental research to accumulate additional knowledge regarding the stomatognathic musculature.

Moyers, 1949, a pioneer in the dental field studied the neuromuscular system of mastication with the help of electromyography. He observed the pattern of spike potentials in the muscles of mastication, particularly the temporalis, and analyzed it before and after treatment of Angle Class II, Division I malocclusions. On completion of the orthodontic treatment, i.e. restoration of the normal position of the teeth, he found that the pattern of spike potentials was different. He then concluded that the position of the teeth alters the character of the spike potentials or the activity of the muscles.[34]

Using electromyograph, in 1956, Jarabak[35] confirmed for certain patients that the etiology of muscle spasms lies in the occlusion of the teeth. The neuromuscular activity of temporalis muscle was studied on a group of patients, with and without the placement of an interocclusal splint. This splint was built up in order to eliminate the interocclusal interference. Before treatment, electromyographic studies showed a greater neuromuscular activity at rest, after biting, than on subjects without muscle spasm.

But during treatment, the spontaneous activity at rest, after biting, disappears when the activity pattern corresponds to that of a normal subject. Clinically, the pain in the muscle took more time for elimination. The electromyographic data obtained from the neuromuscular activity supports the following statement: "muscle spasms may come from occlusal interferences, associated with temporomandibular joint disturbances".

In 1956, H. Spuntoff and W. Spuntoff studied electromyographically the centric occlusion position and the physiologic rest position by the technique that they called "visual feed-back".[36] Based on the principle enunciated by Perry[48], that the physiologic rest position is equated with the lowest order of activity produced by a negligible number of motor-units, they instructed their patients to place the mandible in a specific position according to the lowest pattern recorded on the electromyograph. The physiologic rest position was obtained by maintaining the pattern of "electrical silence" in the electromyograph.

In 1958, Lundquist concluded from a myographic study on seventeen subjects with natural and artificial dentitions, that the buccinator muscle aids in stabilizing the maxillary and mandibular denture by exercising pressure on buccal flange. This stabilization action was noted on the working side, but not on the balancing side of unilateral chewers. However, this muscle functions bilaterally to stabilize the denture on both sides for bilateral chewers only.[37]

Antje Tallgren, in 1963, examined a sample of six complete denture wearers in order to find the behavior of certain facial and jaw muscles. By comparison of myograms, the investigator stated

that the lower lip muscle and mentalis muscle as well, play a role in the retention and stability of dentures.[38] Furthermore, these muscles exhibited an increased electrical activity during overclosure.

Yemm[39], 1969, concluded from a study of psychogenic aspects of a patient that emotional stress could affect the mandibular posture. The electrical activity of the right masseter muscle during performance of a task was recorded. The task required that the subject press a button corresponding to a random display of lights. Electromyographic activity was noted during the task. Furthermore, the magnitude of this increase was related to the number of errors made by the subjects.

In later studies, Hannam et al., 1969, established that EMG activity immediately ceased when tooth contact was established, or an electromyographic silent period, after tooth contact. The silent period obtained with edentulous patients wearing complete dentures[40] was identical to that of subjects with natural teeth.[41] This suggested that some other mechanisms, such as muscles spindles or receptors in the temporo-mandibular joints, other than mechanoreceptors in the mucous membrane, are involved in the response of tooth contact.

Thomas[42] has however shown that the muscle activity of the elevator musculature becomes silent during electrical stimulation of the periodontium or palate. Furthermore, Taylor and Davey[43], 1968, have demonstrated that elevator muscle spindles become continuously active during the closing phase of mastication, due to gamma activation and it is difficult to believe that the spindle

afferents are not firing also during this stage. Yet a "silent period" is clearly delayed until the opening phase commences. The subject is obviously highly controversial.

It is therefore assumed that the electromyograph is sensitive enough to be used to record electrical muscular activity.

INSTRUMENTATION

Electromyographic Equipment:

The electromyographic equipment employed in this study was made by Harvard Apparatus Co. Inc., Millis, Mass., and is illustrated in Fig. 1. This recording system consists of a variable chart mover (model 850), two bioamplifiers (model 355), one time-event marker plus a two-channel pen-writing crystograph (model 350), which was driven by a synchronous speed reducing motor. This motor was capable of producing twelve exact paper speeds from 0.0025 to 12.5 cm/second. The paper used in the chart-movers was a millimeter grid paper-roll, 10 inches wide by 200 yards long, No. 2460. The recording module had a frequency response of 0.25 c.p.s. and a maximum sensitivity of 40 millivolts per centimeter of pen deflection. The bioamplifier increased the sensitivity to 20 microvolts per centimeter of pen deflection.

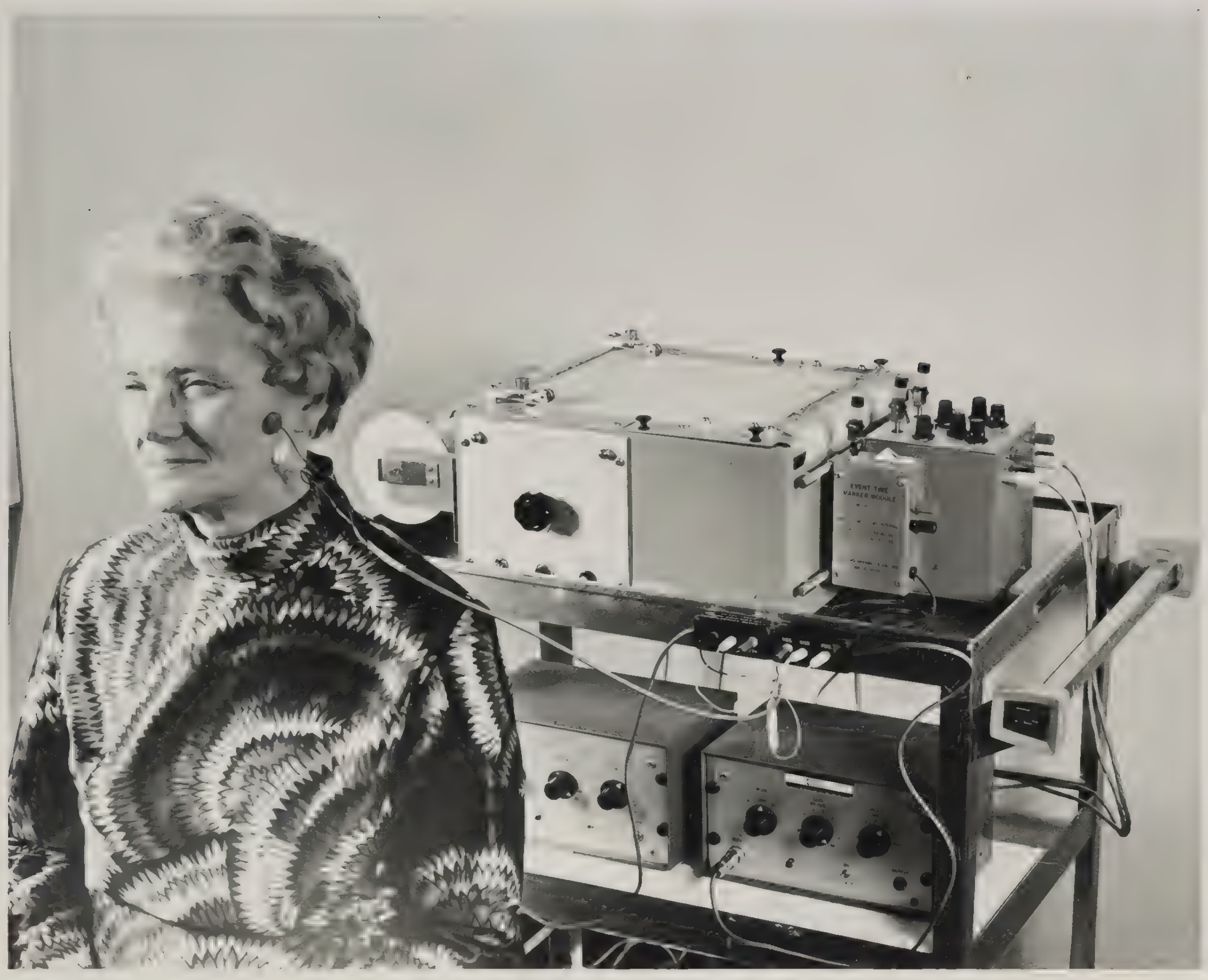

Figure 1. Electromyographic Equipment: The crystograph ink writing recorder is placed on the top shelf of the trolley; the bioamplifiers are located on the bottom shelf of the trolley; also, electrode-position is illustrated over the masseter muscle (left side); the ground (not shown) is attached to the back of the neck.

Electrodes

Beckman biopotential skin-electrodes were used. They consisted of a circular perforated silver disk, enclosed in a light weight plastic case with an inside and outside diameter of 9 mm and 19 mm respectively, and they were 5 mm thick. Skin resistance, using these electrodes, can be as low as 300 ohms depending on how the skin is preconditioned, resulting in a decrease in "electrical-noise" interference.

The following material was used to attach the electrodes to the skin:

a) Surgical sponge

b) Ethyl alcohol 95%

c) Adhesive collar

d) Warm water

e) Beckman electrode-paste

f) Plastic syringe with a blunt 20-gauge needle

Swivels and Springs:

The stainless steel swivels and springs were manufactured by Claudius Ash Company of England. The swivels are composed of two parts, the "body" and the "arm". The "body" of the swivels (measuring 10 mm in length, 5 mm in height, and 1 mm in thickness) includes two "legs" that can be bent inwards to facilitate its retention in the acrylic resin (Fig. 2). The "arm" of the swivel, fixed to the center of the "body" with a rivot, is 12 mm long. One "stop", located on each side of the rivot, at the base of the "body", reduces the swivel freedom of movement to 200 degrees.

The springs, 50 mm long, and with an inside diameter of 0.055", have approximately 100 spiral coils (Fig. 3). The steel wire consists of nickel, chromium, carbon, maganese, sulfur, and phosphorus. The gauge of the wire has 0.020" diameter and a tensile strength of 130 tons/sq inch.[44]

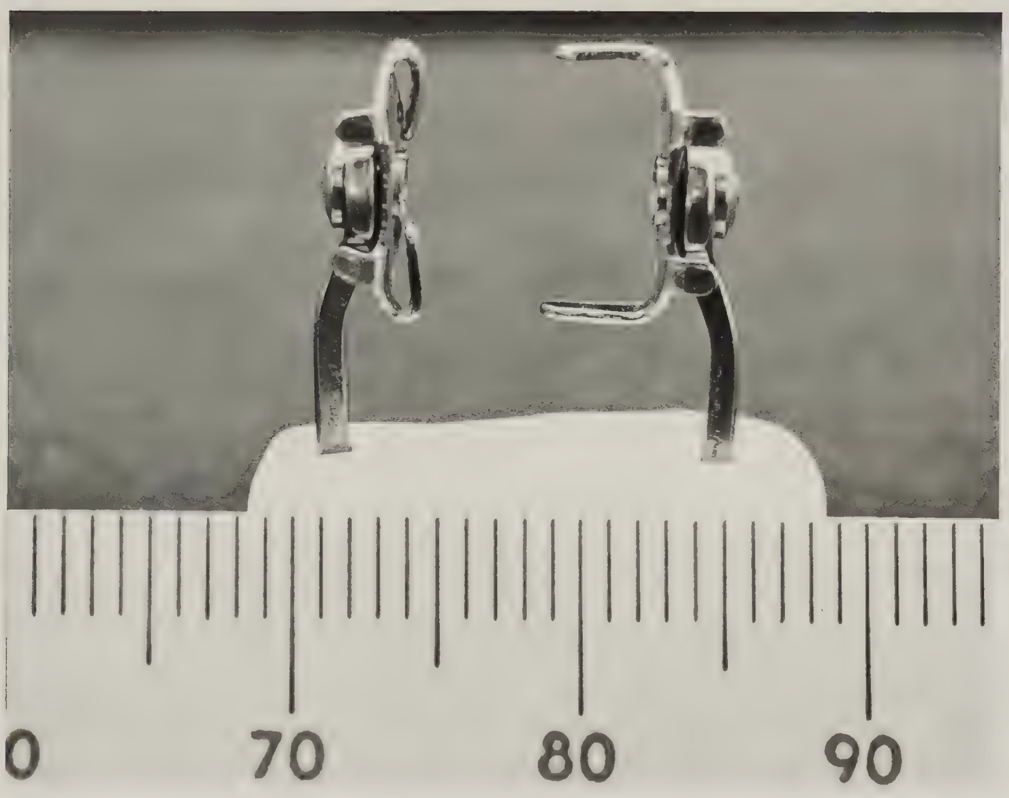

Figure 2. Left Swivel: "legs" of the "body" bent for increasing retention in acrylic resin.

Right Swivel: "legs" of the "body" unfolded as received from the manufacturer.

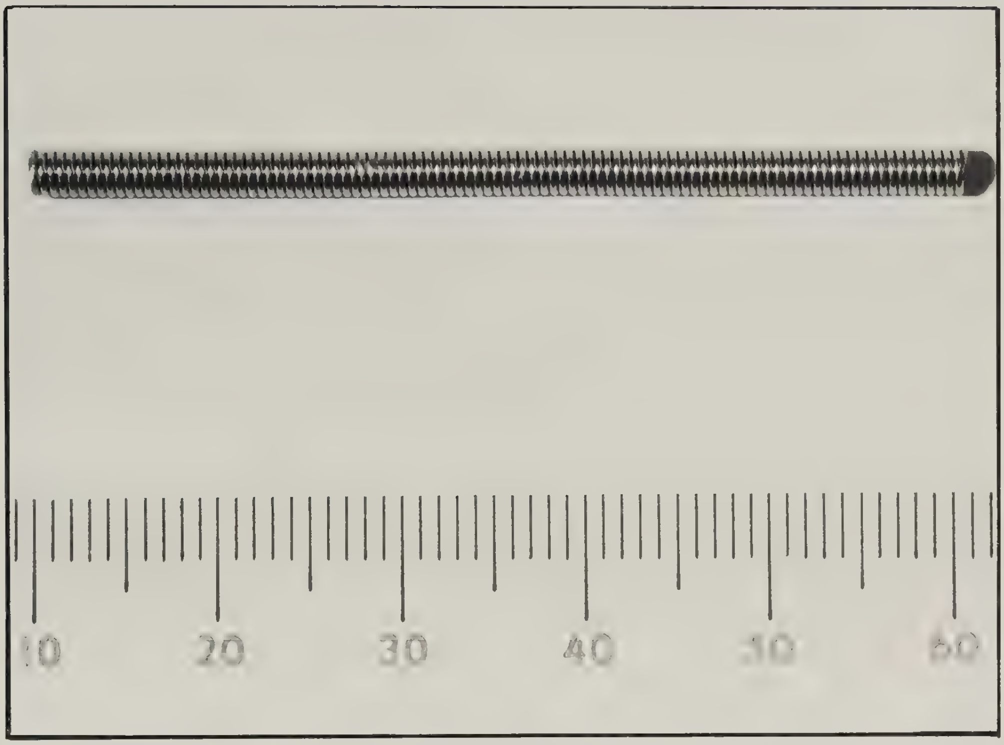

Figure 3. Ash's Spring.

Dynamometer:

The tension that the spring exerts against the maxillary denture and the mandibular denture was measured by means of a dynamometer*. The range covered by this dynamometer was from 10 to 100 grams. The tension recordings were obtained from an enclosed unit consisting of a white dial-face and black etched graduations (Fig. 4).

This dynamometer was mounted in a jig (metal base 4 1/2" x 7") in such a way that it simulated the spring-relation in the mouth. A swivel was fixed to the feeler-tip of the gauge, which was placed at right angles to a graduated slide. A metal block which was recessed in a channel parallel to the graduated scale had a swivel attached to it. This metal block was readily moved from right to left adjacent to the scale. The distance between the feeler-tip at rest, and the right extremity of the recessed channel was 70 mm. The scale was calibrated in mm, and from this, the spring-tension at various inter-swivel distances was recorded.

---

* Alina Correx Tension Gauge, manufactured by Swiss instruments, 3700 Santa Fe Ave., Los Angeles, Calif.

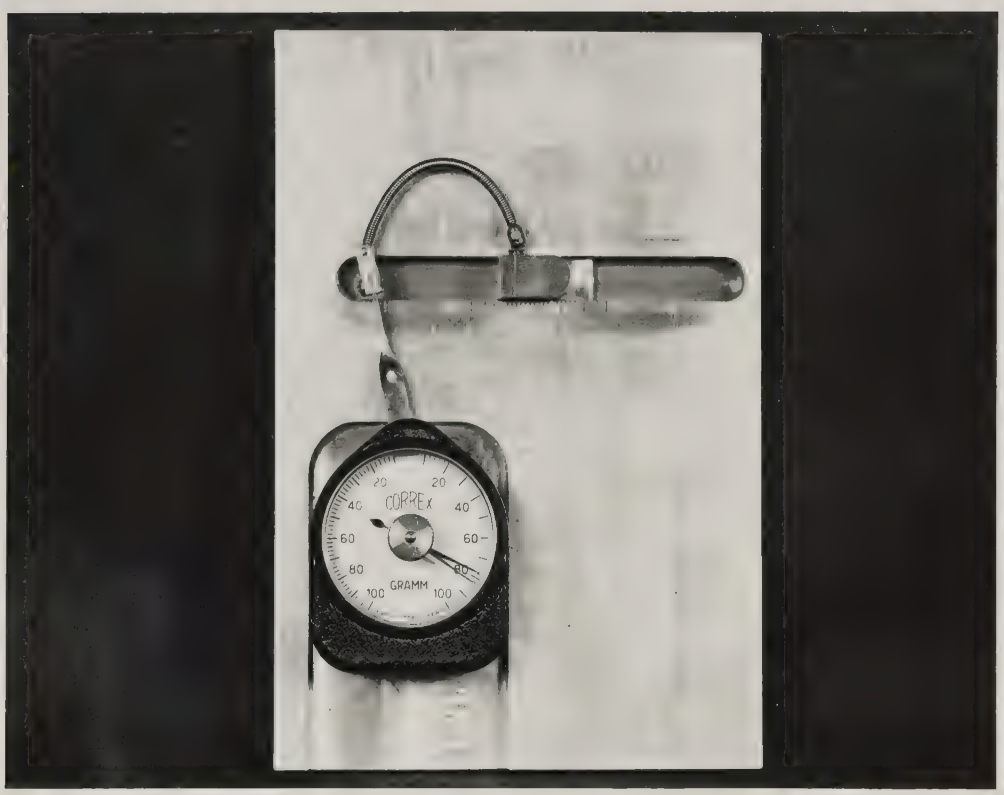

Figure 4. Dynamometer: Base, with gauge, and note increasing spring-tension being recorded by the movement of the recessed sliding block (moving from right to left) adjacent to graduate scale.

METHODOLOGY

Selection of the Subjects:

Five edentulous subjects, ranging in age from 23 to 60 years, were selected: two males and three females. The males did not wear dentures previously, while the females did. The selection of these patients was based upon the following criteria: no clinical evidence of neuromuscular disturbances, no clinical evidence of temporo-mandibular joint dysfunction, and a mesiognathic jaw relationship.

Construction of the Dentures:

The construction of the dentures for all the patients was verified by the same instructor in the Department of Prosthetic Dentistry at the University of Alberta. The following is a brief description of the clinical and laboratory procedure.

Preliminary impressions were taken with irreversible hydrocolloid and preliminary casts were poured. Custom trays were made of activated acrylic resin for making the final impressions. The trays were border molded with low fusing modeling plastic, spaces were made for the impression material, and the final impressions were made with a zinc-oxide eugenol impression paste. Master casts were then poured, and baseplates with wax occlusion rims were constructed. The tentative vertical dimension of occlusion and tentative centric relation records were then made. Fast-setting plaster was used for recording interocclusal records (Direct Method).

A face-bow (Hanau Model "C") record was registered and the casts mounted on a Hanau Model H-2 articulator. Protrusive interocclusal plaster records were used to adjust the horizontal condylar inclination. The type of posterior tooth used was a plastic non-anatomic (flat plane) "Rational"*. Zero degree teeth were selected to minimize a possible effect on electromyographic activity[45], from displacement of denture bases under spiral spring tension.

The second molar was positioned as a balancing ramp, providing three points of contact in eccentric movements. Centric occlusion, vertical dimension, balanced occlusion and esthetics were verified clinically. Next, the dentures were waxed up and the swivels added to the upper and lower dentures.

The site of the upper swivels was determined for all patients in the following manner:

The incisive papilla and the vibrating line (located between the levator veli palatini and the tensor palatini) were located onto the cast. A line was drawn to join these two points. The cast was then marked at a point located 1/3 the length of this line distal to the anterior margin of the incisive papilla (Fig. 5). Next a perpendicular line running through this latter point was drawn and extended onto the land area of the cast. The swivels were placed into the wax of the buccal flanges at this antero-posterior location.

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* Trubyte Biotone, Dentsply International Inc., York, Penn., U.S.A.

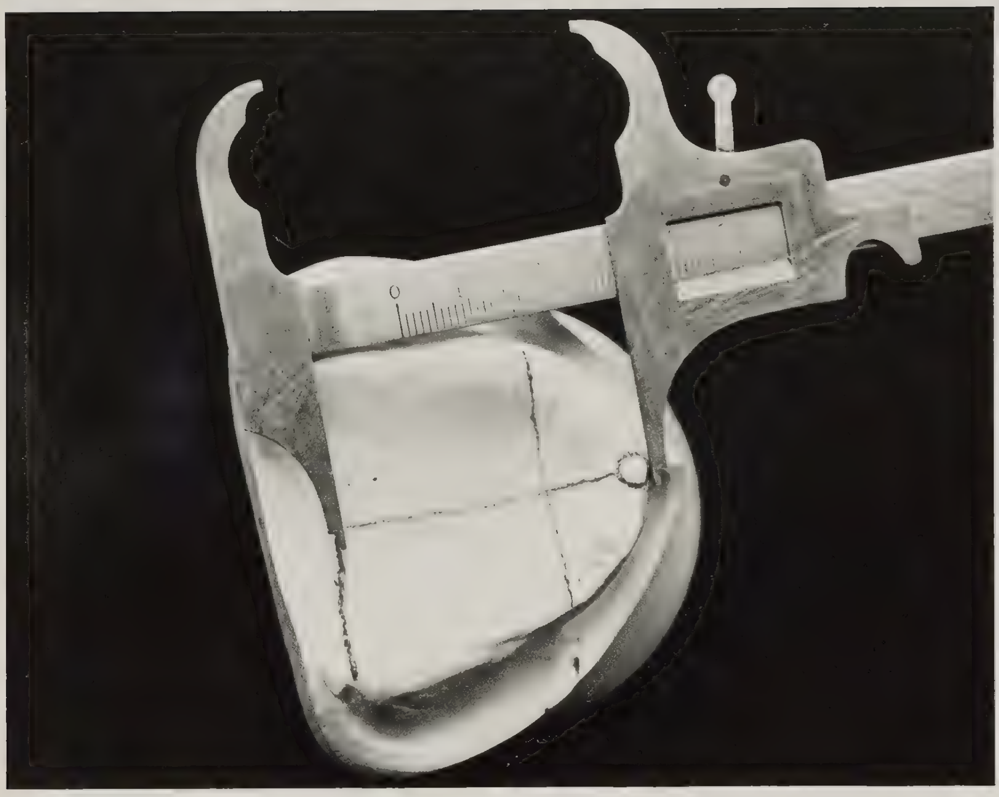


Figure 5. Antero-posterior Location of Upper Swivels.

The site of the lower swivels was determined for all patients in the following manner:

A line was drawn from the center of the upper "swivel-location" extending down to the land area of the mounted mandibular cast. This line was made at a right angle to the occlusal plane. Next, a point 5 mm anterior to this line was marked on the land area. The mandibular swivels were placed into the wax of the buccal flanges at this antero-posterior location (Fig. 6).

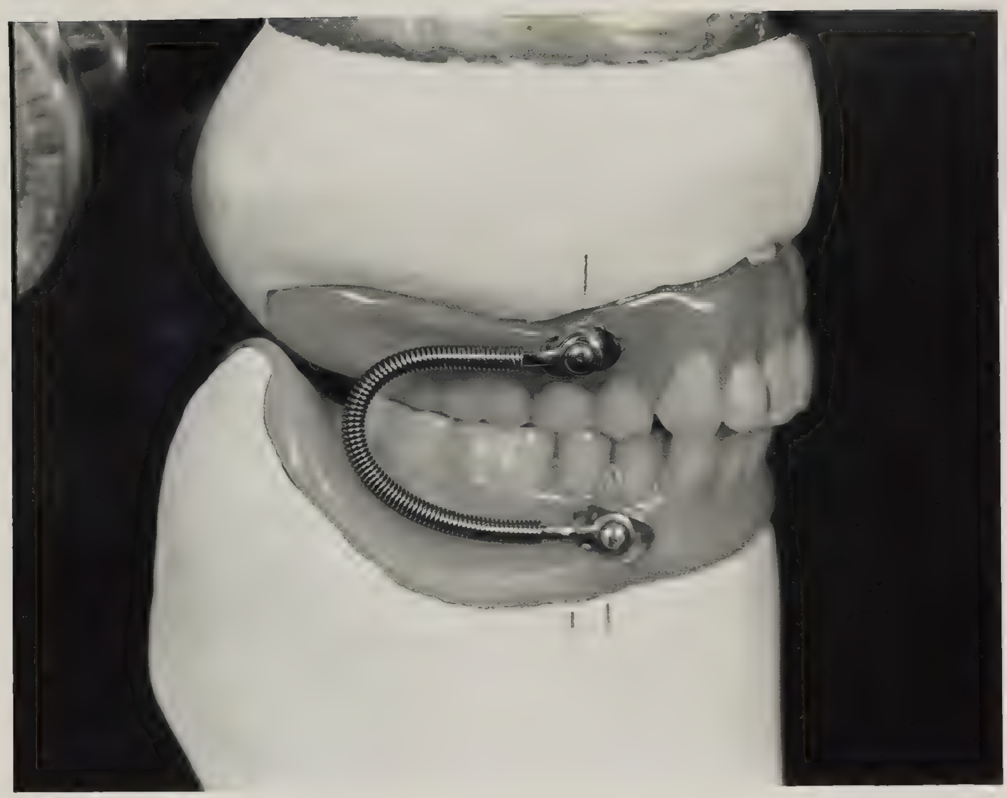


Figure 6. Location of the Lower Swivels

Next, the denture bases were processed using the "fluid resin" technique described by Sheppard.[46] Prior to investing the denture bases into the reversible hydrocolloid, a mixture of stone (20 mm long, 20 mm height, 5 mm thick) was placed over the four swivels as shown in Fig. 7. Care was taken to completely relieve the stone from the occlusal surface of the teeth. The reversible hydrocolloid was then poured. When the gelation and cooling of the hydrocolloid were complete, the cast with the denture was recovered. The teeth, the wax, the cast, and the block of dental stone covering the swivels, were separated from each other. The dental stone with the embedded swivels was replaced in the hydrocolloid mold after being thoroughly cleansed (Fig. 8).

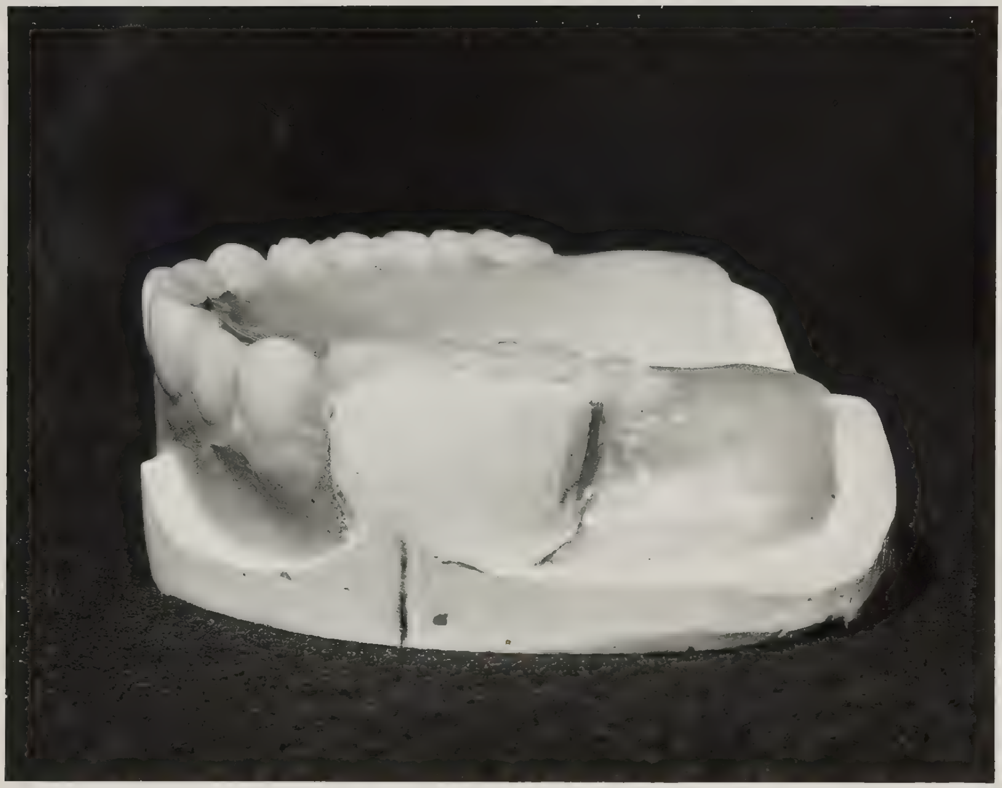


Figure 7. Swivel Covered by Dental Stone.

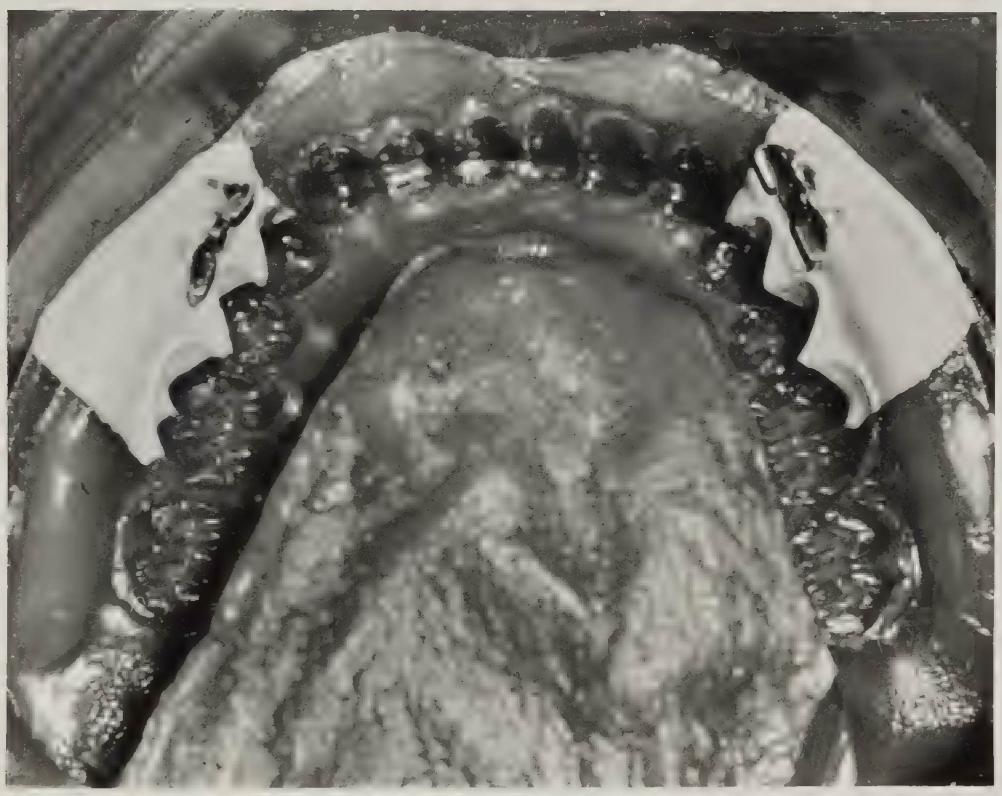


Figure 8. Stone and swivels replaced into the hydrocolloid mould.

After recovering the dentures, remount casts were constructed. A new interocclusal record in centric relation was obtained and the dentures were remounted on the articulator in order to compensate for occlusal discrepancies due to processing. Occlusal corrections were made on the articulator before insertion.

Preliminary Preparation of the Subjects:

The subjects wore their dentures for three weeks before testing to eliminate discomfort or "sore spots". The subjects were appointed and were given preliminary explanations on electrode placement, machine function, and the recording procedure. It was emphasized that the amount of electrical current involved was very small, and therefore the procedure was completely safe.

Selection of Muscles and Attachment of Electrodes:

A review of muscle anatomy and physiology indicated that the masseter muscle would be a suitable muscle for this study. Bipolar surface electrodes were attached bilaterally over the masseter muscles to record the electrical activity. The location of the electrodes over the masseter muscles was selected, as suggested by Greenfield and Wyke.[47] The Frankfort horizontal plane was used as the first line of reference; a vertical line at right angles to this first line, passing through the anterior surface of the external auditory meatus, was drawn as the second line of reference:

The _anterior masseter_ electrode was placed 35 mm anterior

to the vertical line, and 25 mm below the horizontal line.

The *posterior masseter* electrode was placed 23 mm anterior to the vertical line, and 45 mm below the horizontal line.

The two electrode-areas determined above were cleansed and rubbed with a surgical sponge (saturated in 95% alcohol) in order to remove grease and the keratinized layer of the skin, and to produce erythema. The Beckman electrode paste was introduced through the central opening of the electrode, using a plastic syringe with a blunt 20 gauge needle. The surface electrode was kept in position over the muscle by means of an adhesive collar. The location, the cleansing, and the positioning of the opposite masseter surface electrodes was identical. The ground electrode was attached to the skin at the back of the neck at the level of the 6th cervical vertebra.

Electromyographic Recording Procedure:

The patients were placed in an unshielded room, and seated on a plain back chair in an erect position, without head support nor arm rest. The hands were placed on the knees and the feet flat on the floor. The head was held in such a way that the Frankfort plane was parallel to the floor. The eyes were closed to restrict visual distraction and for optimum concentration.[48]

The crystograph pen and the bioamplifier had separate amplification-adjustments. Specific adjustments were made for each subject (with and without springs). Once the degree of amplification was determined it was maintained for the duration of the test-sessions.

The surface electrodes were placed over the masseter muscles (as previously described) so that the electrical activity, from the contractions of the muscles, was recorded. The electrical changes were transmitted from the muscles to the electromyograph for amplification. The circuit, from the patient to the bioamplifier, was constructed so that there was a low inherent noise level. The five wires (two from each muscle, plus the ground) were inserted into an insulated rubber tube. The amplified voltage was recorded on the crystograph; therefore the bilateral muscle activity could be compared at any specific time or interval.

The patient was first instructed to relax his jaw (physiologic rest position), then to close on his back teeth (centric occlusion), and to apply moderate occlusal pressure for five seconds. The subject was then instructed to relax.

When the subject fully comprehended this testing sequence, the bioamplifiers were switched on, and the crystograph turned on with the paper speed gear set at 0.625 cm/sec.

Two conditions were established in comparing the neuromuscular response of the masseter muscle. The first condition consisted of recording the action potential from the masseter muscle when the patient was applying moderate occlusal pressure with springs attached to the dentures. The second condition was the same as the first but without springs attached to the dentures. This gave the opportunity to produce myograms during isometric contraction of the masseter muscle in centric occlusion. It was also noted that it was impossible to observe total electromyographic silence. The subject informed the investigator by means of a hand signal when

he deviated from the established testing procedure.

Twenty electromyographic recordings were made each test-session; i.e. ten with springs, and ten without springs. A time-interval of fifteen minutes was provided to each subject between the two conditions. During that period, an evaluation of the spring tension was made with the dynamometer (described in Fig. 4).

All following sessions were carried out daily, for ten successive days, for each subject.

The surface electrodes were removed with gauze saturated with alcohol, and the cheek rubbed with warm water. The patient was dismissed and instructed to wear the dentures during the day, but to remove them at night.

Statistical Treatment of the Data:

The amplitude of the action-potential of myograms obtained from the five subjects clenching with and without springs was recorded (Fig. 9). The paper on which the myograms were printed was ruled in square millimeters. Each tracing obtained was calculated according to the number of square millimeters (Fig. 10). For each muscle the data was tabulated from 10 tracings with and without springs, for five subjects, each day for ten successive days (Table I - X).

It was recognized that results provided by five subjects may not be truly representative of the population as a whole. The conclusions drawn were considered with this fact in mind. The type of data, the small sample size, and the limited number of test sessions influenced the statistical analysis decided upon.

The treatment plan is shown on Table XXI. The statistical model used was a three factors analysis of variance with days as replicates.[66] The result of analysis of variance is shown in Table XXV.

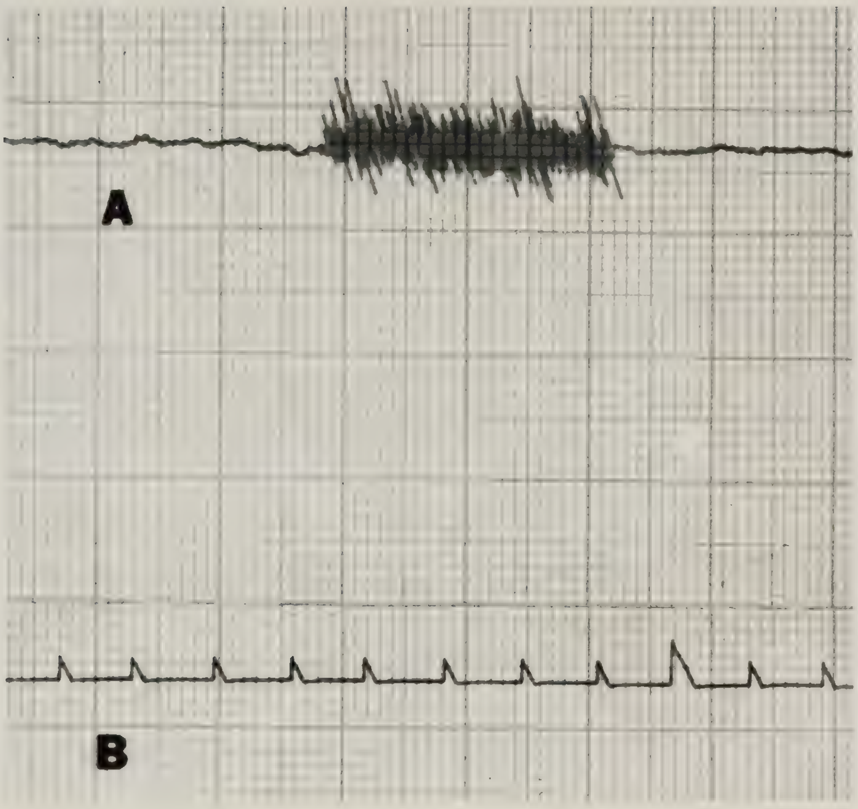


Figure 9. "A" Typical electromyogram obtained from isometric contraction of the masseter muscle.

"B" One-second base-line time-marker.

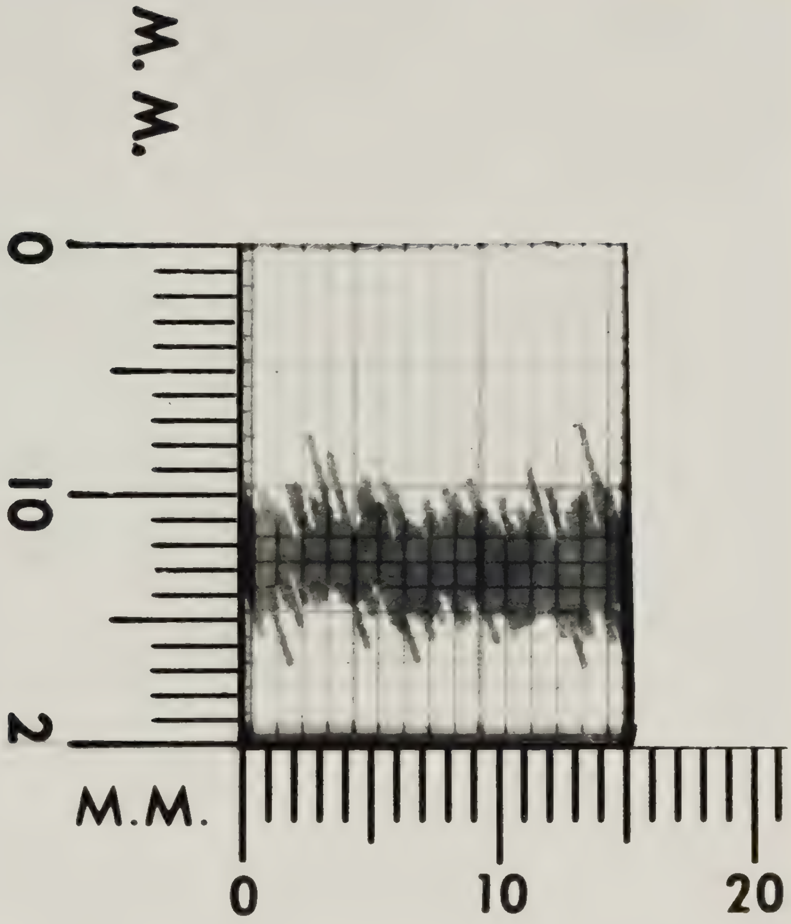


Figure 10. Method of measuring the electromyogram area (mm^2) recorded by the recording stylus (through a horizontal distance of 15 mm, and a vertical distance of 20 mm).

RESULTS

1. WITHOUT SPRINGS vs WITH SPRINGS

The performance of all subjects (Table I - X) without springs was compared to the performance of all subjects with springs.

Analysis revealed that the degree of electromyographic activity was smaller with springs than without springs (Table XXV), $P < .01$. This result is also demonstrated graphically (Fig. 11).

Analysis revealed also no significant difference between a) springs and subjects, b) springs and muscles, and c) springs, muscles, and subjects.

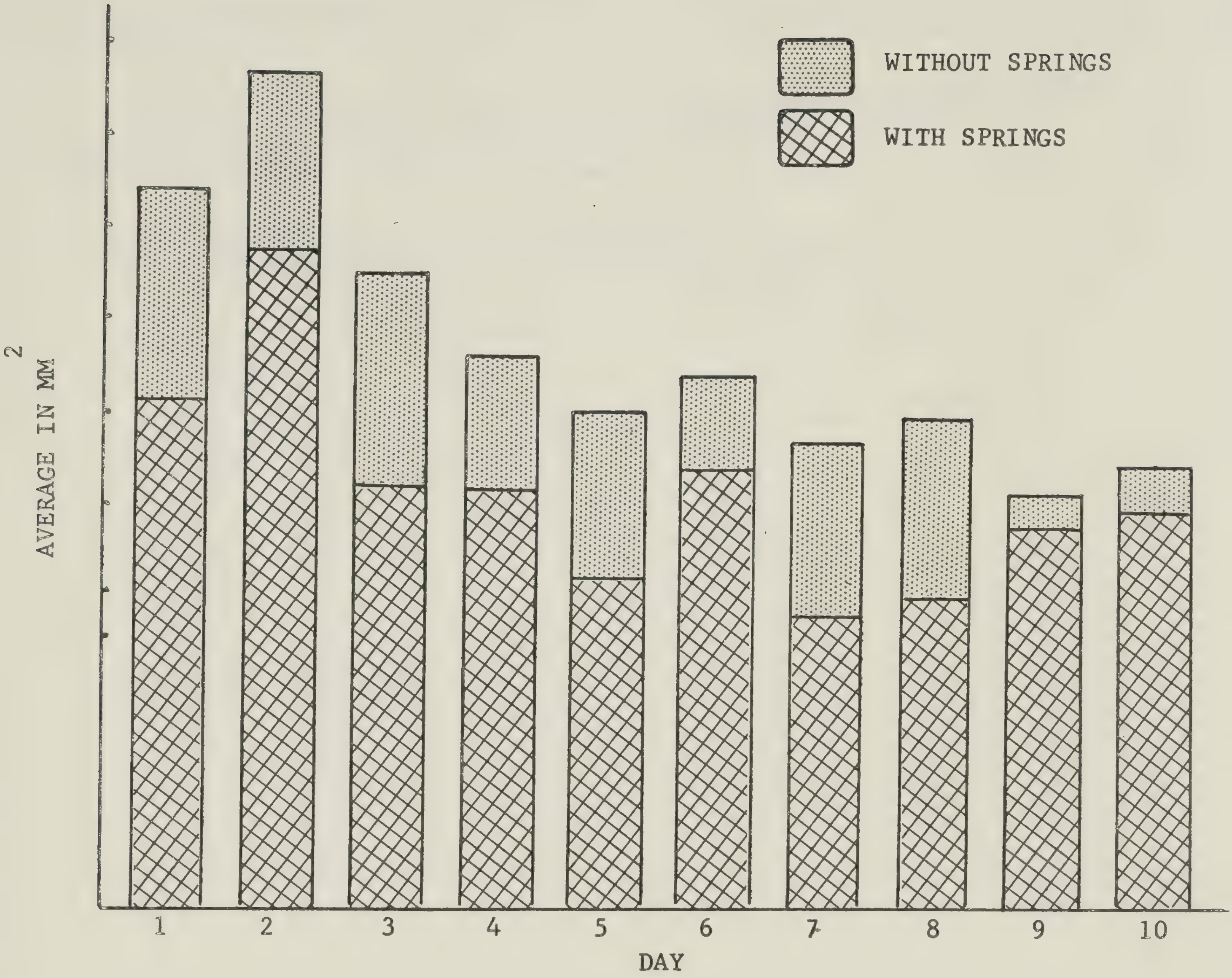


Figure 11. Mean EMG performance comparing "with springs" to "without springs" (Table XXII).

2. DAILY VARIABILITY

The total EMG performance for ten daily test-sessions was recorded (Table I - X). These data were subjected to statistical evaluation (Table XXV).

Analysis revealed that the daily EMG performance showed significant changes in daily performance, $P < .01$.

The pattern of these changes is shown in Figure 12.

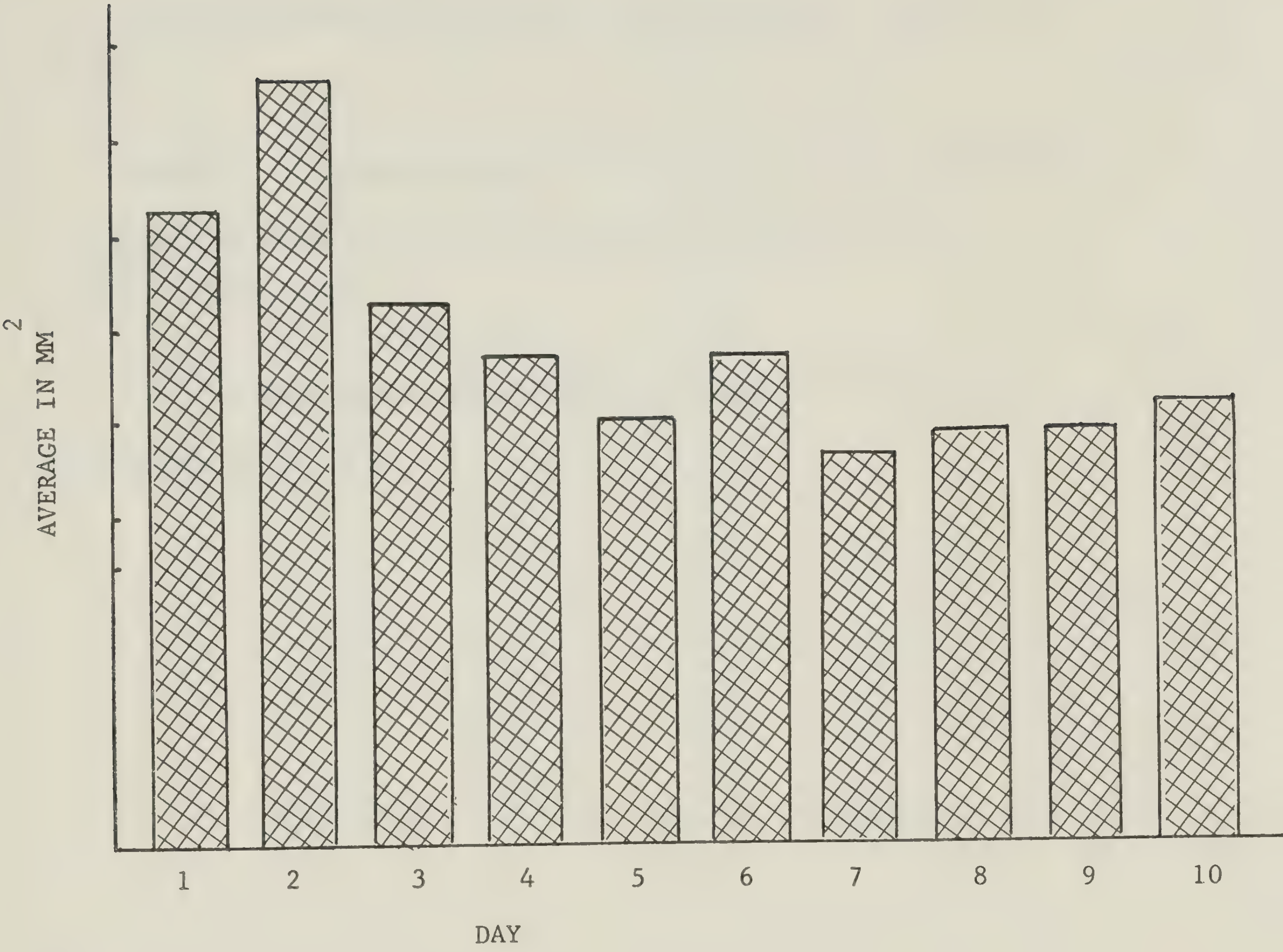


Figure 12. Mean EMG performance (combining five subjects, left plus right masseter muscles, with plus without springs) for each day (Table XXII).

3. PATIENT VARIABILITY

The total EMG performance for five subjects was recorded (Table I - X). These data were subjected to statistical evaluation (Table XXV).

Analysis revealed significant difference among subjects, $P < .01$.

However, the interpretation of this effect is confounded with a significant interaction between subject and muscle groups, $P < .01$. (Table XXV)

The mean individual subject EMG performance was also shown graphically (Fig. 13).

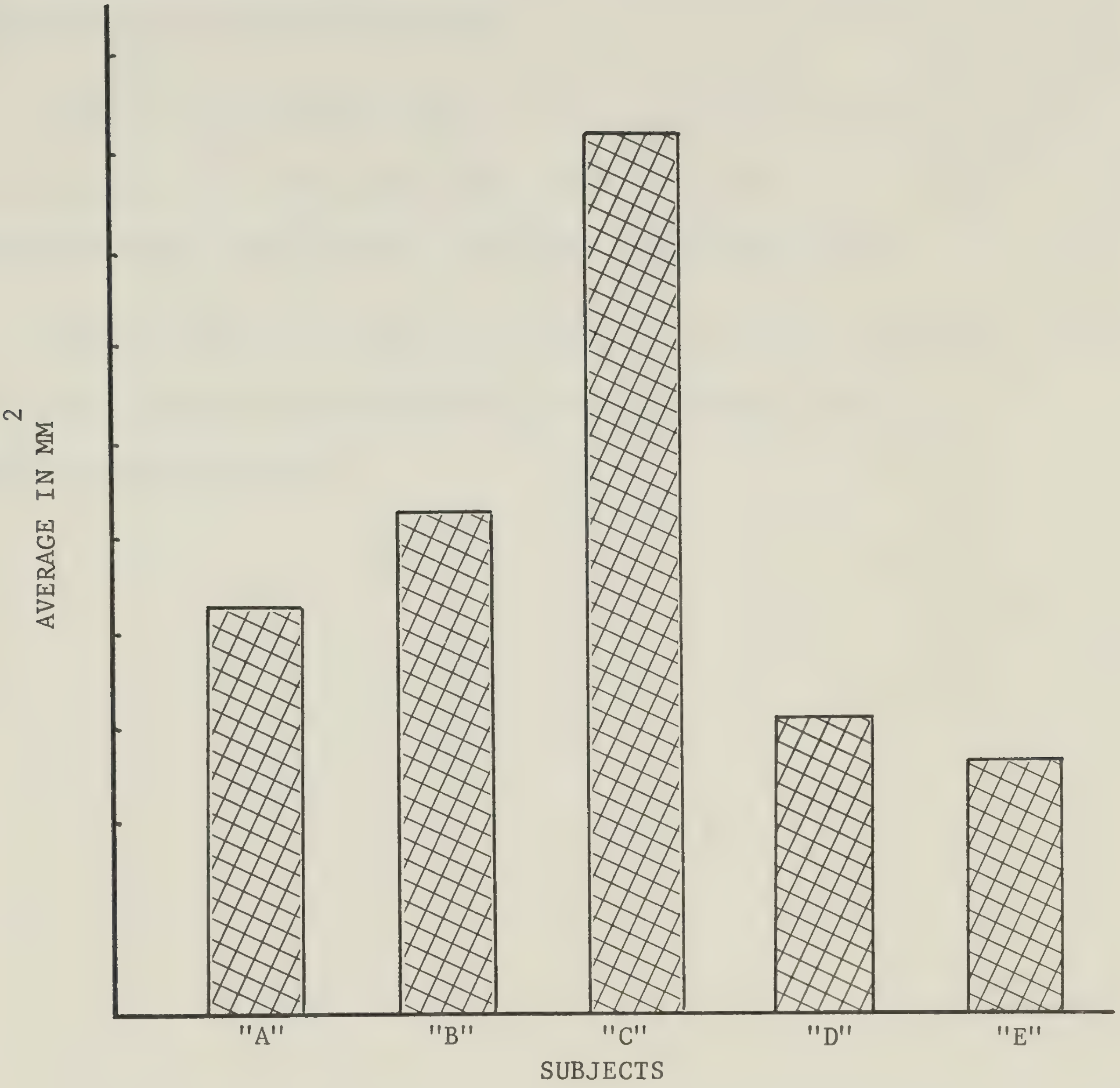


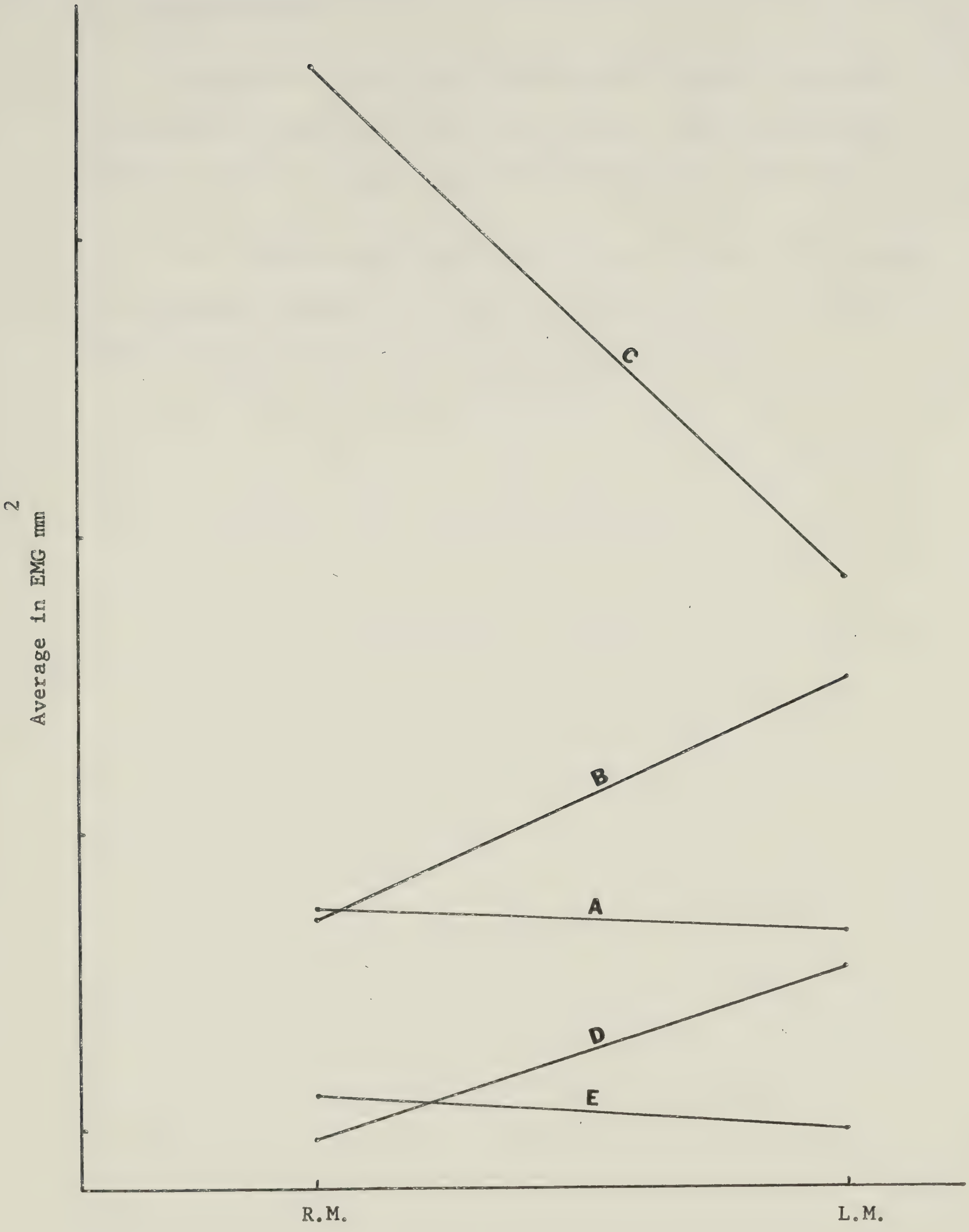
Figure 13. Mean EMG performance (with plus without springs, left plus right masseter muscles, for ten days) for each subject (Table XXIII)

4. SUBJECT BY MUSCLE INTERACTION

The total EMG performance for the interaction of subject by muscle was analyzed (Table XXV).

While no significant difference was found between left and right muscles as a main effect (Table XXV) a significant interaction was found between subject by muscle (Table XXV).

This is borne out in Figure 14, when it is demonstrated that different subjects showed differing balances between left and right muscles EMG means.



Mean EMG performance of the right and left masseter muscles showing subjects and muscles interaction.

R.M. = Right Masseter L.M. = Left Masseter

5. SPRING-TENSION

A dynamometer (Fig. 4) was constructed to record, in grams, the amount of tension exerted by each spring, daily for ten days, for five subjects. These data were recorded (Table XI to XX).

It was observed that the amount of tension exerted by a spring was relatively constant, with only a slight decrease in tension being observed between the first and tenth testing day.

DISCUSSION

The significant difference between the muscle activity with and without springs, in this study, agrees with the findings and theories of Sherrington[49], Kawamura[50], Granit[51], Griffin and Munro[52]. These workers reported an inhibition of motor neurons of the mandibular elevators when the teeth are occluded, i.e., when oral receptors are stimulated. Their results suggest that in the silent period following stretch of the muscle spindles or when periodontal receptors are stimulated by the occlusion of teeth, the opening muscles contract at some stage during the period of inhibition of the mandibular elevators.

The nerve to the masseter muscle contains both sensory and motor fibers. The sensory nerve fibers originate in special endings known as the muscle spindles and form afferent pathways to the central nervous system to synapse with the motor neuron or efferent pathway to the muscle.

In this study, when the subject closes his jaw from rest to centric occlusion, the masseter muscle contraction is resisted by external agents or stimuli viz: the spiral springs. The sensory endings such as pressoreceptors within the oral mucosa, muscle spindles located within the muscle, and the Golgi tendon organs within the tendons at the point where it joins the muscle, send impulses to the mesencephalic nucleus V, signalling information as to the muscle tonus etc. Through central connections of the mesencephalic motor nucleus

V, the muscle spindle tension readjusts to the pressure exerted by the spring along the masseter muscle. During the first two or three days, the adjustment appears to be poor and the stretch reflex appears exaggerated and masseter activity is increased. Presumably, the spindle length subsequently adjusts to the spring pressure by elongation or relaxation of the intra fusal fibers. Consequently, feed back from the spindles to the motoneuron decreases during clenching and fails to augment or reinforce alpha motoneuron activity, hence resulting in a gradually reducing electromyogram (Fig. 11). For full implication of this explanation we need to consider the property of alpha and gamma coactivation during mastication.

This phenomenon is enhanced by the receptors in the periodontal ligament.[53-54] However, in this study, periodontal receptors are eliminated because the subjects are edentulous. According to Griffin and Munro[52], it is probable that stimuli from receptors, other than the periodontal receptor, can cause reflex inhibition of the elevator muscle, such receptors in the palate[49-55], mucoperiosteum[56], and temporo-mandibular joint.[57]

The function of these receptors is to grade and control mandibular movements, therefore, it is presumed that in these subjects, as the mandible closes from rest vertical dimension to centric occlusion, the spring tension related to oral mucosa causes a contraction of the neuromusculature of the depressor.[50] The effect of this is to reciprocally inhibit the elevator musculature.

It is beyond the scope of this study to observe the

neuromuscular behavior of the digastric muscle, but an electromyogram from this muscle under spring tension will probably clarify the relationship of this muscle in respect to elevator activity.

Furthermore, the response of the elevator muscle is not entirely dependent upon the alpha motor neuron. Its activity is also dependent upon the gamma efferent system[59] as influenced by the central nervous system and peripheral impulses from, for instance, the oral mucosa.

Granit[51] has demonstrated that there is a co-activation or co-inhibition of alpha and gamma motor neurons (the extra and intra-fusal fibers respectively). The gamma efferent neuron system is regulated to a large degree by descending tracts from several areas of the brain. Stimulation of pressoreceptors in the oral cavity (oral mucosa) whether by noxious agents, gingival stimulation, or pressure from spiral spring tension on the denture bearing mucosa, increase the gamma efferent discharge to reflexly inhibit the elevator muscle activity and facilitate contraction of the depressor musculature.[60]

Although the difference between with and without springs appears fairly consistent over the ten days testing period, the bar graph (Fig. 11) indicates that masseter muscle activity shows less variation between with and without springs after the eighth day. By examination of the Fig. 11 an obvious mean difference in activity obtained with and without springs for the first eight days is observed, but by the ninth and tenth day, the difference in activity is less. This may be an indication that good adaptation has occurred by the ninth and tenth day for this subject. This, suggesting adaptation to the

springs, is reasonably complete toward the end of the testing period.

To summarize, it might be suggested that the chronic stretch exerted on the muscle spindle over a period of time (eight days) has raised the threshold of firing of the muscle spindle.

Furthermore, the chronic stimulation of oral receptors (gingiva, temporo-mandibular joint, etc.) may contribute to this adaptation. Thus by the ninth day, the neuromuscular system has adapted to the with spring situation; and even when the springs are removed, the overall muscle activity is similar to the without spring activity. It is further possible that the threshold of alpha motoneurons may be directly influenced by the modified activity of the central nervous system that accompanies continuous stimulation of the chronic spring tension. This will in turn result in a decreased elevator muscle contraction.

However, a longer testing period would probably bring more positive results regarding this decreased differential activity with and without springs.

Regarding the highly significant difference in the muscle activity with and without springs of the overall subjects, the explanation may be one or all of the following: firstly, the variation in activity is probably related to a subject's interpretation of what is meant by moderate clench , in centric occlusion, with and without springs attached to their dentures. Secondly, for each subject, slight adjustments were necessary in

setting up the crystograph and the bioamplifier prior to recording. When the acceptable degree of amplification was determined (4 - 9 mm of pen-ink deflection), this level was maintained for the duration of the test session over the ten days period. The wide range of amplification (4 - 9 mm) was necessitated by the fact that for certain subjects (e.g. Subject "C") a 4 mm level could not be achieved. Thirdly, it is of some interest to note by inspection of the means data (Table I to X), that for all subjects, the difference between the with spring and without spring activity tended to increase for the sixth and seventh days which coincided with the weekend, i.e. Saturday and Sunday. This might suggest that adaptation is rhythmic in nature. In addition, the increased weekend activity suggests the subjects unwillingness to participate in an experiment over the weekend and it is to be expected that marital stress would be further exacerbated at such a time when husband and wife are both at home. In at least one case (Subject "D"), there were significant indications of the latter. These suggestions are consistent with the observation that muscle tone increases during emotional stress and psychic tension (Yemm[39], Benson and Gedye[61]).

The significant difference obtained for the interaction of patients by muscles receives ready explanation on the grounds of anatomical and/or physiological asymmetry between the sides. The asymmetry may in part be explained as follows. Firstly it may be inferred that subjects A, D, and E (Fig. 14), who have been denture wearers prior to the testing situation, were already partially adapted to the condition of denture wearing, whereas subjects B

and C who had no previous experience of dentures were not. Some support for the latter may be seen in the fact that the difference in the EMG activity between the right and left masseters were considerably greater for Subjects B and C than for A, D, and E.

But the sex difference of the subjects confounds any attempt to show a statistical effect of denture familiarity.

With reference to the enhanced muscular activity during the first three days (Fig. 11) in association with the complaint of muscle soreness during this time in four of the subjects, it may be suggested that in selected cases a muscle relaxant (e.g. Methyl carbinol, robaxin) be administered for the first three days.

It is reasonable to anticipate that variation in spring tension over the ten days testing period would influence muscle reaction. However, it was found (Table XI to XX) that the difference in tension between the first and tenth day was negligible for both right and left sides.

To conclude the study, it may be summarized that the reflex arc involving the muscle spindle, the oral pressoreceptor, the sensory nerves, the synapses, the reciprocal inhibition and excitation as well as the motor supply seem to be the mechanism through which muscle activity and its adaptation occurs.

There is considerable controversy in the literature regarding the central location of the synaptic events of the above reflex mechanism. Jerge[53] claimed that some of the synapses are situated in the supra-trigeminalis nucleus V between the mesencephalic proprioceptor nucleus V and the mesencephalic motor

nucleus V. Thomas[42] suggests that fibers, particularly those innervating molar periodontia in the rat, may synapse at an internuncial neuron before connecting with the motor nucleus V. It is also suggested by Thomas[42] that the inhibition of digastric activity in the rat by the muscle spindle afferents lies at the level of the mesencephalic sensory nucleus V. Nakamura and Wu[62] have also provided evidence that cat digastric alpha motoneurons are directly inhibited by masseter motoneuron activity.

Furthermore, as might be expected, it is apparent that the brain, midbrain, and cerebellum have considerable influence in the control of motor activity and also in the control of sensation.[63]

Granit and Kaada[64] pointed out that the cerebellum acts through both alpha motoneurons and the gamma fusimotor neurons by stimulation of the anterior lobe of the cerebellum. They also demonstrated that the efferent gamma system is tonically activated from central regions and that stimulation of various central nervous structures influences the afferent discharge from the muscle spindle.

Ruch and Patton[65] discussing the problem state: "So knowledge of the higher control of tonus via gamma efferent is a new development which may in future explain some of the puzzling features of abnormal tonus states."

CONCLUSION

(1) It is apparent from this study that alteration of complete dentures by the addition of spiral springs has an effect upon the functional activity of the masseter muscle.

(2) The performance of the right and left masseter muscles measured by EMG activity over a ten successive day testing-period varied as a function of the patient tested.

(3) The addition of spiral springs to a denture resulted in a reduction of the electromyographic activity during isometric contraction of the masseter muscles, when compared with the activity without springs. The difference was statistically significant.

(4) The reduced electromyographic activity is considered to be an adjustment process involving central effects of receptor activity from the muscles tendons, joints, and oral cavity upon the muscles of mastication (masseter). It is hypothesized that gamma efferent activity is decreased as part of the mechanism of reduced muscle activity.

(5) It is suggested that emotional stress and psychic tension influence muscle tonus, thereby giving rise to increased electromyographic activity.

(6) It was suggested by the data that, as a result of adaptation to the experimental conditions, progressively less difference in EMG activity between with and without spring conditions would occur over time.

(7) It is anticipated that the initial denture might provoke a greater difference in EMG activity between the right and

left masseter muscles in subjects who have never worn dentures than in those who have.

(8) "Spring tension" remained virtually constant over the ten-day testing-period.

(9) It is suggested that a muscle relaxant might be prescribed to a patient receiving complete dentures with springs.

(10) The above studies should be extended to include other muscles of mastication such as the digastric muscle. It would be advantageous to extend the testing period to include at least two weekends and also to study the behavior of the right and left masseter muscles when initial dentures are inserted.

APPENDIX A

TABLE I

EDENTULOUS SUBJECT "A"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE RIGHT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	105	149	118	175	133	151	112	105	157	155	136.0
2	85	78	110	100	115	106	114	113	128	121	107.0
3	47	53	53	65	67	60	78	62	63	67	61.5
4	77	66	66	73	66	67	64	67	72	78	69.6
5	80	88	79	72	107	84	85	91	57	65	80.8
6	117	99	116	92	110	106	106	126	116	98	108.6
7	70	72	49	65	66	69	61	78	92	56	67.8
8	78	75	69	61	67	75	90	84	87	79	76.5
9	44	44	53	55	48	48	53	46	56	72	51.9
10	69	64	76	61	72	62	68	72	49	52	64.5

WITHOUT SPRINGS

DAYS	SURFACE MM^2										MEANS
1	232	153	162	134	156	113	104	117	142	111	142.4
2	181	122	134	153	143	136	134	99	141	143	138.6
3	57	54	41	49	45	57	49	55	72	43	52.2
4	64	53	106	89	84	79	91	88	84	86	82.4
5	79	98	71	60	56	80	80	75	75	82	75.6
6	96	108	94	93	108	127	120	109	101	114	107.0
7	93	100	86	84	81	85	82	81	82	80	85.4
8	93	105	93	75	68	85	77	60	65	63	78.4
9	62	90	47	57	70	74	76	72	89	85	72.2
10	81	92	103	81	94	84	89	65	85	101	87.5

TABLE II

EDENTULOUS SUBJECT "A"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE LEFT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	121	151	100	160	169	129	172	114	153	131	140.0
2	94	95	95	99	83	101	127	98	107	93	99.2
3	75	76	77	78	72	82	73	73	69	91	76.6
4	90	86	79	100	98	88	88	89	76	90	88.4
5	81	100	71	75	83	82	78	85	51	73	77.9
6	73	62	74	93	106	84	97	98	93	86	86.6
7	55	69	61	67	75	72	80	78	92	60	70.9
8	63	54	52	58	54	51	55	45	50	49	53.1
9	72	61	60	61	64	70	68	67	71	79	67.3
10	54	62	60	50	87	60	79	71	58	55	63.6

WITHOUT SPRINGS

1	137	146	95	118	149	106	186	117	137	136	132.7
2	114	122	124	68	98	105	120	59	112	120	104.2
3	54	48	57	53	74	58	57	51	48	40	54.0
4	82	72	90	76	83	93	100	92	67	107	86.2
5	64	78	63	65	67	76	72	72	73	106	73.6
6	126	77	106	97	116	104	106	81	98	90	100.1
7	101	99	80	109	120	105	97	109	111	95	102.6
8	46	59	53	55	47	59	52	56	48	37	51.2
9	96	88	90	88	84	80	72	70	81	65	81.4
10	53	69	63	49	48	60	47	45	54	45	53.3

TABLE III

EDENTULOUS SUBJECT "B"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE RIGHT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	123	102	92	73	120	123	119	114	137	111	111.4
2	137	94	146	142	103	90	125	139	118	126	122.0
3	131	137	115	93	86	82	78	120	98	91	103.1
4	63	103	102	136	105	77	72	88	99	83	92.8
5	100	52	31	53	33	96	57	90	52	70	63.4
6	81	79	102	148	106	82	105	118	98	70	98.9
7	103	42	38	31	18	41	29	40	37	47	42.6
8	57	63	59	52	37	44	45	37	39	44	47.7
9	39	53	49	48	59	74	94	60	51	59	58.6
10	50	42	38	36	31	29	34	59	32	30	38.1

WITHOUT SPRINGS

1	155	214	165	177	171	180	160	154	192	177	174.5
2	158	121	119	115	116	104	139	137	133	157	129.9
3	141	121	148	107	108	157	119	125	118	96	124.0
4	121	163	79	102	146	103	125	152	90	132	121.3
5	108	104	72	87	63	97	125	76	85	109	92.6
6	63	111	85	68	67	62	72	83	69	72	75.2
7	99	96	66	52	60	60	59	50	40	39	62.1
8	47	67	59	45	51	53	49	44	45	50	51.0
9	46	53	52	55	44	44	51	46	38	37	46.6
10	83	75	58	62	63	45	44	46	49	43	56.8

TABLE IV

EDENTULOUS SUBJECT "B"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE LEFT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	138	112	43	100	104	126	134	115	149	113	113.4
2	129	100	98	137	92	97	135	140	98	134	116.0
3	136	144	179	120	131	118	134	154	121	137	137.4
4	109	116	130	153	109	111	97	140	159	96	122.0
5	137	72	67	37	69	157	110	138	113	126	102.6
6	159	96	142	178	135	148	114	146	123	106	134.7
7	186	137	128	95	95	95	111	121	122	150	124.0
8	142	127	97	73	79	98	73	66	72	81	90.8
9	88	91	103	102	113	90	120	99	106	124	103.6
10	87	54	68	76	78	72	67	169	101	95	86.7

WITHOUT SPRINGS

1	151	189	132	169	151	195	134	142	168	169	160.0
2	139	149	159	160	159	166	153	201	148	203	163.7
3	200	174	229	193	202	200	183	194	173	156	190.4
4	135	132	118	110	174	115	123	154	118	173	135.2
5	125	149	134	99	154	124	144	106	134	129	129.8
6	97	124	135	118	90	117	145	110	109	122	116.7
7	188	193	110	110	183	169	119	143	144	149	150.8
8	199	151	174	204	187	199	123	131	168	116	165.2
9	87	86	83	103	95	75	74	83	75	78	83.9
10	135	110	126	101	117	75	80	84	77	81	98.6

TABLE V

EDENTULOUS SUBJECT "C"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE RIGHT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	172	116	100	143	106	122	136	107	131	118	125.1
2	252	282	280	237	276	263	255	254	248	244	258.5
3	234	211	260	212	211	205	191	214	226	196	216.0
4	181	211	211	243	178	245	213	249	210	234	217.5
5	235	242	252	218	229	218	249	208	262	190	230.3
6	227	237	206	261	223	232	244	224	213	245	231.2
7	202	183	211	186	171	204	215	204	224	186	198.6
8	174	173	199	201	204	239	225	232	190	194	203.1
9	221	181	203	222	231	226	224	172	207	220	210.7
10	238	264	288	269	284	237	275	253	269	271	264.8

WITHOUT SPRINGS

1	130	139	156	207	131	124	129	167	151	125	145.9
2	261	221	240	255	236	220	249	262	243	274	246.1
3	231	270	247	259	257	251	268	276	260	253	257.2
4	268	278	275	268	277	271	290	255	270	254	270.6
5	240	235	254	267	273	264	269	274	238	235	254.9
6	268	266	256	250	275	244	258	233	248	249	254.7
7	235	215	264	235	217	257	228	220	236	203	231.0
8	257	261	225	256	251	241	256	267	242	238	249.4
9	262	277	254	251	265	245	219	238	221	237	246.9
10	257	275	279	285	293	276	270	284	271	286	277.6

TABLE VI

EDENTULOUS SUBJECT "C"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE LEFT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	182	162	161	90	126	177	181	151	218	201	164.9
2	184	197	196	207	181	211	214	202	145	170	190.7
3	167	129	136	97	158	62	94	122	113	129	120.7
4	91	141	88	171	118	140	126	149	88	150	126.2
5	69	95	100	110	97	119	113	119	114	121	105.7
6	128	86	119	124	138	124	133	125	136	121	123.4
7	108	82	128	75	65	96	101	112	88	123	97.8
8	149	174	152	113	118	170	205	130	205	166	158.2
9	167	137	200	170	172	164	175	126	146	157	161.3
10	141	117	159	140	150	104	124	127	87	145	129.4

WITHOUT SPRINGS

1	149	161	163	173	164	143	166	174	205	191	168.9
2	207	235	234	199	185	167	194	182	186	207	199.6
3	126	203	153	142	205	198	137	158	153	148	162.3
4	99	98	102	120	132	117	144	145	113	91	116.1
5	128	108	137	120	159	122	170	138	146	117	134.5
6	147	139	122	119	143	202	106	114	152	130	137.5
7	78	68	119	75	99	94	111	118	120	109	99.1
8	116	146	152	153	163	132	145	202	147	177	153.3
9	149	158	180	187	225	186	213	176	173	208	185.5
10	164	105	152	136	116	135	111	163	119	129	133.0

TABLE VII

EDENTULOUS SUBJECT "D"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE RIGHT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	83	81	50	55	68	47	58	48	43	45	57.8
2	51	43	42	52	70	46	55	52	54	45	50.9
3	45	43	46	38	37	36	41	36	40	36	39.8
4	41	48	41	50	49	43	39	30	36	34	41.1
5	37	35	29	32	34	36	34	32	35	32	33.6
6	30	37	29	29	32	26	34	27	33	32	30.9
7	31	37	34	33	36	28	28	26	29	30	31.2
8	45	39	39	38	35	36	30	35	35	44	37.6
9	36	27	31	30	34	27	31	30	23	26	29.5
10	50	48	50	52	36	51	45	50	46	47	47.5

WITHOUT SPRINGS

1	75	71	79	49	79	55	81	59	81	72	70.1
2	108	90	79	76	66	79	59	71	63	80	77.1
3	113	98	97	67	66	70	67	114	68	80	84.0
4	50	52	49	49	38	50	54	51	53	56	50.2
5	60	58	34	35	42	38	48	51	43	44	45.3
6	72	81	58	79	55	51	45	53	96	66	65.6
7	51	39	46	34	32	31	33	35	39	50	39.0
8	53	70	54	50	51	40	41	50	47	65	52.1
9	39	29	38	30	34	34	31	34	30	39	33.8
10	75	62	55	53	54	61	75	56	60	62	61.3

TABLE VIII

EDENTULOUS SUBJECT "D"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE LEFT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	85	96	63	57	65	46	70	50	35	48	61.5
2	67	68	55	51	65	54	70	61	71	53	61.5
3	90	102	94	100	80	92	82	76	74	78	86.8
4	41	62	66	61	68	59	60	47	72	42	57.8
5	59	57	43	47	63	59	63	48	55	79	57.3
6	62	55	48	46	39	45	73	43	76	49	53.6
7	83	74	72	63	76	49	59	65	56	49	64.6
8	56	51	52	53	46	54	53	51	61	64	54.1
9	59	64	48	61	80	67	95	79	75	83	71.1
10	108	92	98	110	79	108	136	147	125	151	114.7

WITHOUT SPRINGS

DAYS	SURFACE MM^2										MEANS
1	90	78	82	66	102	69	98	90	73	85	83.3
2	153	133	113	122	100	113	98	100	104	116	115.2
3	124	102	118	109	121	126	113	141	145	127	122.6
4	89	72	62	55	50	50	61	56	43	53	59.7
5	98	94	82	52	67	58	84	80	71	70	75.6
6	78	91	68	96	72	86	75	91	95	84	83.6
7	92	70	69	59	81	66	79	96	95	90	79.7
8	52	68	79	81	65	68	76	81	80	78	72.8
9	89	58	81	72	65	65	64	65	83	75	71.7
10	81	114	117	93	95	70	88	108	113	95	97.4

TABLE IX

EDENTULOUS SUBJECT "E"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE RIGHT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	64	54	66	47	44	56	53	36	47	41	50.8
2	84	50	76	78	98	84	80	62	97	105	81.4
3	28	32	34	33	27	48	53	25	44	40	36.4
4	65	66	35	41	42	42	57	58	53	52	51.1
5	48	45	39	43	39	42	44	26	29	32	38.7
6	34	30	29	37	33	41	24	22	32	29	31.1
7	39	29	36	53	58	52	40	46	38	24	41.5
8	46	34	29	35	37	31	33	28	27	29	32.9
9	76	82	78	62	66	90	58	81	69	86	74.8
10	53	50	49	42	67	66	58	51	41	37	51.4

WITHOUT SPRINGS

1	98	85	78	93	76	87	70	74	78	78	81.7
2	87	76	84	86	85	76	107	95	130	87	91.3
3	71	61	48	32	41	26	37	55	62	56	48.9
4	78	65	71	58	69	47	67	66	65	45	63.1
5	71	62	75	56	59	56	84	62	55	45	62.5
6	47	39	36	38	71	33	33	47	36	68	44.8
7	72	72	57	75	84	79	70	72	45	62	68.8
8	57	55	57	37	64	51	58	55	51	65	55.0
9	70	67	67	71	73	70	70	53	86	65	69.2
10	36	47	43	66	71	48	38	68	43	32	49.2

TABLE X

EDENTULOUS SUBJECT "E"

"MEAN" MEASUREMENTS OF ELECTRICAL ACTIVITY, OVER TEN DAYS, OF THE LEFT MASSETER MUSCLE WITH AND WITHOUT SPRINGS.

WITH SPRINGS

DAYS	SURFACE MM^2										MEANS
1	46	37	34	48	47	75	66	28	42	45	46.8
2	86	74	63	67	85	81	85	76	81	106	80.4
3	31	34	37	46	31	39	49	34	43	36	38.0
4	74	79	47	40	27	42	51	55	49	47	51.1
5	30	28	31	33	28	23	27	24	17	19	26.0
6	28	27	28	38	43	48	44	52	37	46	39.1
7	37	30	32	34	33	32	43	35	29	30	33.5
8	50	49	33	50	45	42	36	33	44	39	42.1
9	50	48	49	51	42	41	34	43	38	42	43.8
10	35	37	40	32	40	44	42	31	34	21	35.6

WITHOUT SPRINGS

1	83	79	72	86	70	90	83	70	75	78	78.6
2	99	110	75	82	88	66	103	131	125	125	100.4
3	48	47	44	48	53	38	47	51	49	53	47.8
4	69	65	66	91	71	48	61	93	93	58	71.5
5	67	70	46	53	54	49	69	42	40	39	52.9
6	41	42	41	45	56	56	57	53	54	66	51.1
7	42	35	40	62	65	43	47	42	34	35	44.5
8	68	74	58	52	79	67	81	54	67	67	66.7
9	24	28	32	29	42	28	28	22	30	23	28.6
10	26	32	25	32	47	41	25	34	30	28	32.0

TABLE XI

EDENTULOUS SUBJECT "A"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE RIGHT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	100	100	100	100	98	97	98	100	96	98
10	98	98	97	98	96	96	96	98	94	96
12	98	98	97	98	97	96	96	97	94	96
14	96	96	94	95	92	94	93	96	93	95
16	95	96	95	94	93	91	94	94	94	95
18	92	94	92	94	90	92	91	92	94	94
20	91	93	91	92	89	90	91	91	92	93
22	90	91	91	88	88	91	90	92	92	92
24	89	91	90	89	88	90	90	91	92	92
26	89	91	90	89	89	90	90	90	92	92
28	88	90	89	91	90	91	90	89	92	92
30	90	92	91	90	86	88	92	90	93	93
32	91	94	93	90	87	90	92	90	94	94
34	94	92	94	92	90	92	92	93	95	95
36	96	96	96	96	92	95	96	96	99	98
37	98	98	98	98	94	96	100	99	101	100
38	103	103	97	103	98	98	103	105	106	106
39	120	120	120	108	104	102	120	120	120	120
40	120	120	120	120	120	120	120	120	120	120

TABLE XII

EDENTULOUS SUBJECT "A"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE LEFT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	98	96	98	96	98	99	98	96	95	94
10	96	94	96	95	96	97	97	96	95	93
12	96	95	95	94	95	96	95	96	91	91
14	95	94	94	94	92	94	89	90	92	89
16	96	91	93	93	90	92	88	89	92	90
18	94	92	92	90	91	93	88	88	90	86
20	93	90	91	89	90	92	86	88	88	85
22	90	90	90	88	89	91	85	87	88	85
24	90	90	89	88	88	90	86	86	87	86
26	88	89	87	89	88	89	87	88	87	85
28	89	89	87	86	87	90	86	87	88	84
30	87	88	86	87	90	90	86	88	86	88
32	87	87	86	86	89	91	86	88	86	90
34	88	88	88	88	92	92	88	88	88	92
36	94	92	92	92	96	96	88	90	90	92
37	98	98	94	94	100	98	90	92	92	98
38	104	94	96	95	102	103	95	96	94	100
39	106	102	102	101	108	112	104	102	102	108
40	120	120	120	120	120	120	120	120	120	120

TABLE XIII

EDENTULOUS SUBJECT "B"

MEASUREMENTS OF SPRING TENSION IN GRAMS,
FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES
(IN MM) FOR THE RIGHT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	110	104	110	105	105	106	102	104	106	102
10	110	103	108	105	105	105	101	104	105	101
12	108	107	108	106	104	104	100	101	102	102
14	104	100	106	102	102	102	98	102	102	99
16	104	98	104	102	102	102	97	100	102	98
18	104	96	102	100	99	102	97	99	100	96
20	103	95	101	99	98	100	97	98	98	94
22	104	94	102	98	98	98	96	99	98	94
24	105	95	102	97	95	100	95	98	99	94
26	104	95	101	100	97	98	95	96	96	94
28	105	94	102	96	95	100	96	100	99	95
30	106	94	104	98	96	100	96	102	102	95
32	110	96	106	102	98	102	98	103	102	96
33	110	97	108	105	98	105	98	104	105	99
34	112	98	114	105	98	108	100	106	110	100
35	120	102	123	106	100	110	103	106	114	103
36	-	106	-	112	106	113	104	108	120	106
37	-	120	-	123	120	120	115	109	-	114
38	-	-	-	-	-	-	120	120	-	120

TABLE XIV

EDENTULOUS SUBJECT "B"

MEASUREMENTS OF SPRING TENSION IN GRAMS,
FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES
(IN MM) FOR THE LEFT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	104	104	102	104	92	101	102	103	84	109
10	104	104	101	104	92	100	102	101	84	108
12	103	103	102	100	100	101	99	99	98	102
14	102	102	98	102	88	98	97	100	78	106
16	101	100	95	99	86	98	98	98	72	105
18	99	99	95	98	86	98	96	96	72	104
20	98	97	95	98	85	97	95	95	70	103
22	98	98	95	96	82	96	95	96	67	101
24	97	97	94	96	82	94	96	96	64	102
26	98	96	95	97	80	94	96	95	62	102
28	97	99	95	94	81	94	96	95	60	103
30	100	98	95	97	81	95	96	96	59	105
32	101	100	95	98	80	97	97	97	54	108
34	103	104	98	100	82	100	100	101	52	116
36	120	112	101	105	81	106	104	106	54	123
37	-	120	106	118	84	118	110	114	-	-
38	-	-	120	125	85	120	120	120	-	-
40	-	-	-	-	94	-	-	-	-	-
41	-	-	-	-	106	-	-	-	-	-
42	-	-	-	-	112	-	-	-	-	-

TABLE XV

EDENTULOUS SUBJECT "C"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE RIGHT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	90	91	91	92	90	92	92	91	92	92
10	89	91	90	90	88	91	90	90	90	90
12	90	90	90	89	88	89	88	90	90	91
14	88	87	88	85	86	87	88	89	90	90
16	86	87	88	87	86	88	87	88	88	88
18	85	86	88	86	84	85	85	86	87	88
20	85	85	86	85	84	86	84	85	86	86
22	84	84	86	84	84	86	84	86	86	86
24	84	84	84	81	82	84	82	84	85	86
26	83	84	84	83	82	84	83	84	84	86
28	85	84	84	83	82	84	84	84	84	84
30	85	84	84	82	82	84	84	83	83	84
32	85	84	84	82	82	82	84	84	84	85
34	86	86	84	83	84	84	86	85	85	86
36	88	88	88	83	84	85	86	88	85	87
38	90	92	90	88	88	89	88	90	88	88
40	95	94	92	90	92	93	92	95	94	94
42	100	100	103	99	102	100	102	105	98	99
43	106	108	110	123	123	125	120	120	104	112

TABLE XVI

EDENTULOUS SUBJECT "C"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE LEFT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	90	91	90	90	91	92	91	90	90	88
10	90	91	90	89	88	91	90	90	88	85
12	89	90	88	90	89	88	87	89	87	84
14	88	88	87	86	87	88	84	88	86	84
16	82	82	86	86	86	86	82	82	84	82
18	80	79	85	85	84	85	81	82	82	81
20	78	80	84	81	82	84	80	81	81	80
22	79	80	84	83	81	80	79	81	81	79
24	81	80	83	80	82	82	78	80	80	78
26	77	78	82	80	81	81	80	80	79	77
28	79	80	80	81	80	79	80	81	78	76
30	80	81	80	79	80	81	80	81	77	76
32	83	83	80	82	82	81	78	81	79	76
34	83	84	84	84	83	84	84	82	79	76
36	84	84	85	84	86	85	86	84	80	78
38	86	87	88	89	90	88	86	86	81	79
40	93	94	96	92	94	92	93	89	84	81
42	110	123	104	112	123	120	120	110	91	86
43	-	-	123	123	-	-	-	120	96	92

TABLE XVII

EDENTULOUS SUBJECT "D"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE RIGHT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	89	90	86	84	86	82	82	82	83	83
10	88	88	85	82	83	82	81	82	82	82
12	89	88	84	82	81	81	80	80	81	81
14	85	86	84	81	80	80	81	80	80	80
16	85	85	83	79	78	80	80	79	80	80
18	84	84	83	78	77	78	79	78	79	78
20	83	83	82	78	76	78	78	77	78	77
22	81	83	82	77	76	76	76	77	77	76
24	81	82	80	76	76	76	74	75	76	76
26	81	81	79	76	76	76	74	75	76	76
28	80	82	79	75	74	76	76	74	76	76
30	83	82	79	75	74	74	75	75	75	76
32	81	82	79	74	74	76	76	74	76	76
34	85	84	81	75	75	76	77	75	77	77
36	84	86	81	75	76	77	78	76	78	78
38	87	88	83	76	78	79	80	77	80	80
40	93	94	91	80	80	82	84	80	84	85
41	99	98	95	86	81	86	88	84	88	90
42	120	112	112	90	89	92	96	96	100	94
43	-	-	-	112	112	94	112	112	123	123

TABLE XVIII

EDENTULOUS SUBJECT "D"

MEASUREMENTS OF SPRING TENSION IN GRAMS,
FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES
(IN MM) FOR THE LEFT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	99	98	98	95	94	94	94	95	95	93
10	96	97	98	95	94	92	92	93	94	93
12	93	94	95	92	93	92	91	92	91	91
14	92	92	94	92	91	90	91	90	89	89
16	92	92	92	91	90	90	91	90	87	88
18	91	90	90	89	89	89	90	90	87	88
20	91	90	92	89	88	88	88	89	86	86
22	90	90	91	86	86	87	88	86	86	85
24	88	89	91	86	86	87	87	87	87	85
26	87	88	90	86	84	86	86	86	86	84
28	88	89	90	86	85	87	86	86	86	86
30	88	89	90	87	84	88	88	87	86	87
32	91	90	92	89	88	88	88	88	88	88
34	90	91	95	91	91	90	90	90	90	90
36	93	94	96	95	96	94	96	93	93	92
38	95	96	100	99	102	100	102	100	98	95
40	104	102	114	110	112	108	114	115	118	105
41	118	112	120	123	123	123	123	123	123	123
42	124	120	-	-	-	-	-	-	-	-

TABLE XIX

EDENTULOUS SUBJECT "E"

MEASUREMENTS OF SPRING TENSION IN GRAMS,
FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES
(IN MM) FOR THE RIGHT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	96	95	92	93	91	92	92	93	92	90
10	96	93	92	91	91	91	91	92	91	90
12	94	92	92	91	90	90	90	89	88	88
14	93	91	91	90	86	88	90	87	87	87
16	92	90	90	89	86	87	89	88	86	86
18	92	89	89	88	86	86	88	87	85	85
20	90	88	88	86	86	86	87	87	84	82
22	89	88	88	86	85	86	86	86	84	83
24	88	87	87	87	85	85	85	86	82	82
26	86	86	86	87	85	84	85	86	82	82
28	86	86	86	87	84	84	84	86	82	82
30	90	87	87	88	85	86	86	85	82	84
32	90	88	87	89	86	86	86	86	82	84
34	91	89	90	90	88	88	88	87	84	86
36	95	91	92	94	90	91	90	90	88	88
38	98	94	95	98	94	95	94	92	93	94
40	112	102	106	108	107	106	102	100	98	118
41	123	108	112	123	123	123	112	106	108	123
42	-	123	123	-	-	-	123	123	123	-

TABLE XX

EDENTULOUS SUBJECT "E"

MEASUREMENTS OF SPRING TENSION IN GRAMS, FOR TEN DAYS, AT VARIOUS INTER-SWIVEL DISTANCES (IN MM) FOR THE LEFT MASSETER MUSCLE.

DAYS

MM	1	2	3	4	5	6	7	8	9	10
9	96	96	96	94	95	90	92	93	91	89
10	95	96	94	93	94	90	90	92	90	89
12	95	94	93	92	93	88	88	90	89	87
14	94	94	92	91	90	86	87	89	86	84
16	94	93	90	89	90	86	87	88	85	82
18	92	92	90	89	88	86	88	87	84	82
20	91	91	89	88	88	86	86	86	83	82
22	90	91	88	87	87	84	86	85	82	82
24	90	90	87	87	87	84	86	85	81	80
26	88	90	86	86	87	83	86	85	80	80
28	88	89	86	86	86	82	84	84	81	80
30	89	90	87	87	87	82	83	84	81	80
32	90	90	87	87	89	84	86	86	82	81
34	91	92	88	88	89	85	88	86	84	82
36	93	93	91	91	92	87	90	87	85	86
38	96	99	97	95	96	91	94	91	88	89
40	106	104	108	106	108	99	100	98	96	98
41	123	123	123	123	123	108	104	102	123	123
42	-	-	-	-	-	123	123	123	-	-

TABLE XXI

MEAN DAILY MEASUREMENTS, WITH AND WITHOUT SPRINGS, FOR ALL SUBJECTS.

SUBJECTS

		A		B		C		D		E	
DAY		R.M.	L.M.	R.M.	L.M.	R.M.	L.M.	R.M.	L.M.	R.M.	L.M.
1	w.s.	136	140	111.4	113.4	125.1	164.9	57.8	61.5	50.8	46.8
	w_o.s.	142.4	132.7	174.5	160	145.9	168.9	70.1	83.3	81.7	78.6
2	w.s.	107	99.2	122	116	258.5	190.7	50.9	61.5	81.4	80.4
	w_o.s.	138.6	104.2	129.9	163.7	246.1	199.6	77.1	115.2	91.3	100.4
3	w.s.	61.5	76.6	103.1	137.4	216	120.7	39.8	86.8	36.4	38
	w_o.s.	52.2	54	124	190.4	257.2	162.3	84	122.6	48.9	47.8
4	w.s.	69.6	88.4	92.8	122	217.5	126.2	41.1	57.8	51.1	51.1
	w_o.s.	82.4	86.2	121.3	135.2	270.6	116.1	50.2	59.7	63.1	71.5
5	w.s.	80.8	77.9	63.4	102.6	230.4	105.7	33.6	57.3	38.7	26
	w_o.s.	75.6	73.6	92.6	129.8	254.9	134.5	45.3	75.6	62.5	52.9
6	w.s.	108.6	86.6	98.9	134.7	231.2	123.4	30.9	53.6	31.1	39.1
	w_o.s.	107	100.1	75.2	116.7	254.7	137.5	65.6	83.6	44.8	51.1
7	w.s.	67.8	70.9	42.6	124	198.6	97.8	31.2	64.6	41.5	33.5
	w_o.s.	85.4	102.6	62.1	150.8	231	99.1	39	79.7	68.8	44.5
8	w.s.	76.5	53.1	47.7	90.8	203.1	158.2	37.6	54.1	32.9	42.1
	w_o.s.	78.4	51.2	51	165.2	249.4	153.3	52.1	72.8	55	66.7
9	w.s.	51.9	67.3	58.6	103.6	210.7	161.3	29.5	71.1	74.8	43.8
	w_o.s.	72.2	81.4	46.6	83.9	246.9	185.5	33.8	71.8	69.2	28.6
10	w.s.	64.5	63.6	38.1	86.7	264.8	129.4	47.5	114.7	51.4	35.6
	w_o.s.	87.5	53.3	56.8	98.6	277.6	133	61.3	97.4	49.2	32

R.M. = right masseter muscle
L.M. = left masseter muscle

w.s. = with springs
w_o.s. = without springs

TABLE XXII

AVERAGE DAILY MEASUREMENTS, WITH AND WITHOUT SPRINGS, FOR ALL SUBJECTS.

EMG

		DAILY MEAN AVERAGE	DAILY MEAN AVERAGE (W. + W_o.S. ÷ 2)	DAILY MEAN AVERAGE DIFFERENCE (W_o.S. - W.S.)
1	W.S.	100.7	112.3	23.1
	W_o.S.	123.8		
2	W.S.	116.7	126.7	19.9
	W_o.S.	136.6		
3	W.S.	91.6	103.0	22.7
	W_o.S.	114.3		
4	W.S.	91.7	98.7	13.9
	W_o.S.	105.6		
5	W.S.	81.6	90.7	18.1
	W_o.S.	99.7		
6	W.S.	93.8	98.7	9.8
	W_o.S.	103.6		
7	W.S.	77.2	86.8	19.1
	W_o.S.	96.3		
8	W.S.	79.6	89.6	19.9
	W_o.S.	99.5		
9	W.S.	87.2	89.6	4.7
	W_o.S.	91.9		
10	W.S.	89.6	92.1	5.0
	W_o.S.	94.6		

W.S. = with springs
W_o.S. = without springs

TABLE XXIII

COMPARISON OF AVERAGE EMG (W.S. + W_o.S. ÷ 2) OVER TEN DAYS, FOR EACH SUBJECT.

EMG

	TEN DAYS AVERAGE		TEN DAYS AVERAGE W. + W_o.S. ÷ 2
SUBJECTS	W.S.	W_o.S.	W. & W_o.S.
"A"	82.4	88.1	85.3
"B"	95.5	116.4	106
"C"	176.7	196.2	186.5
"D"	54.1	72.0	63.1
"E"	46.3	60.4	53.4

W.S. = with springs
W_o.S. = without springs

TABLE XXIV

Comparison of the "MEANS" average EMG of the right and left masseter muscles (W.S. + W_o.S.) over ten days for each subject.

Subjects	R.M.	L.M.
"A"	87.30	83.15
"B"	85.63	126.28
"C"	229.51	143.41
"D"	48.92	77.24
"E"	56.23	50.53

R.M. = Right Masseter

L.M. = Left Masseter

W.S. = With Springs

W_o.S. = Without Springs

TABLE XXV

ANALYSIS OF VARIANCE

Source of Variation	Sum of Squares	D.F.	Mean Square	F	Probability	Tabular F Value
Patients (P)	450,348.44	4	112,587.11	196.75*	P < .01	3.32
Muscles (M)	1,458.	1	1,458.	2.54	P >.01	6.63
Springs (S)	12,183.61	1	12,183.61	21.29*	P < .01	6.63
P X M	97,717.96	4	24,429.49	42.69*	P <.01	3.32
P X S	1,496.95	4	374.24	0.65	P >.01	3.32
S X M	108.93	1	108.93	0.19	P >.01	6.63
P X M X S	1,045.85	4	261.46	0.46	P >.01	3.32
Days	28,026.33	9	3,114.04	5.44*	P< .01	2.41
Error	97,852.06	171	572.23			
Total SS	690,238.12	199				

*Statistical Significant Difference

P = Patients
M = Muscles
S = Springs

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